The Local Politics of Global Sustainability: Envisioning and Creating a Sustainable and Desirable Future

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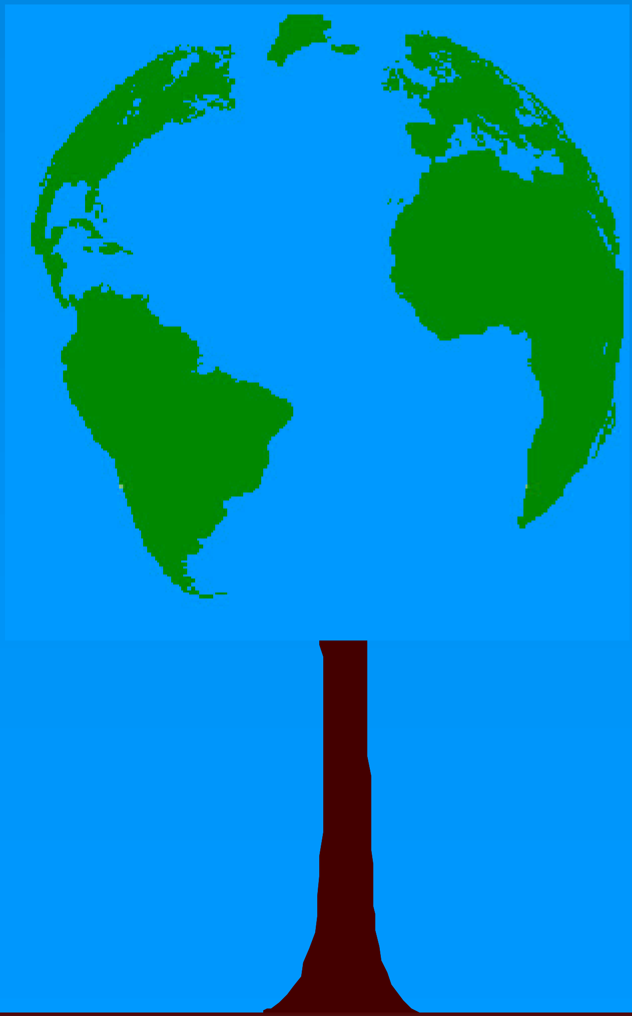
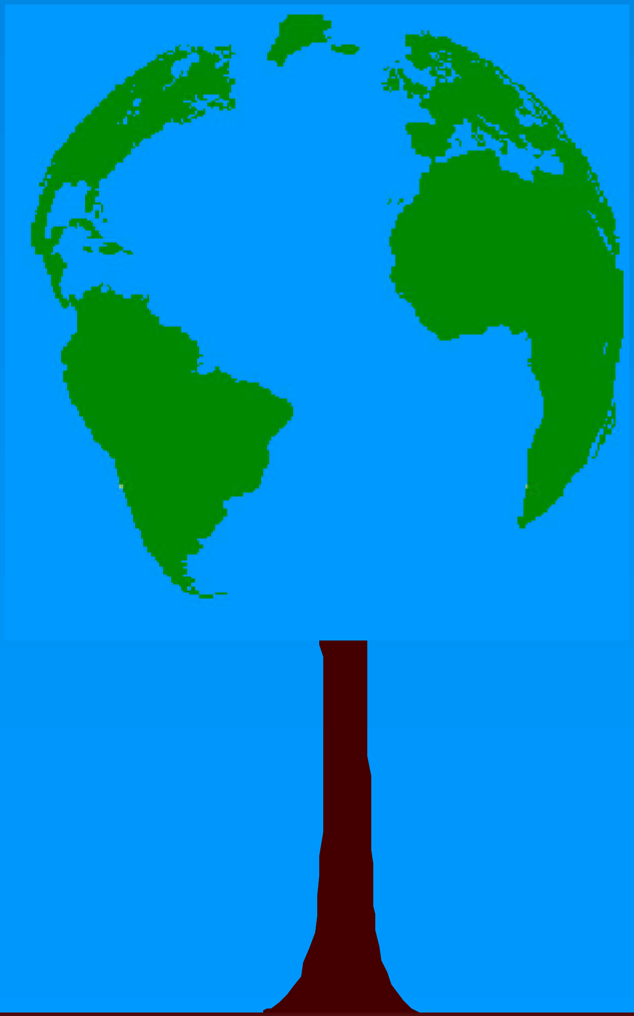
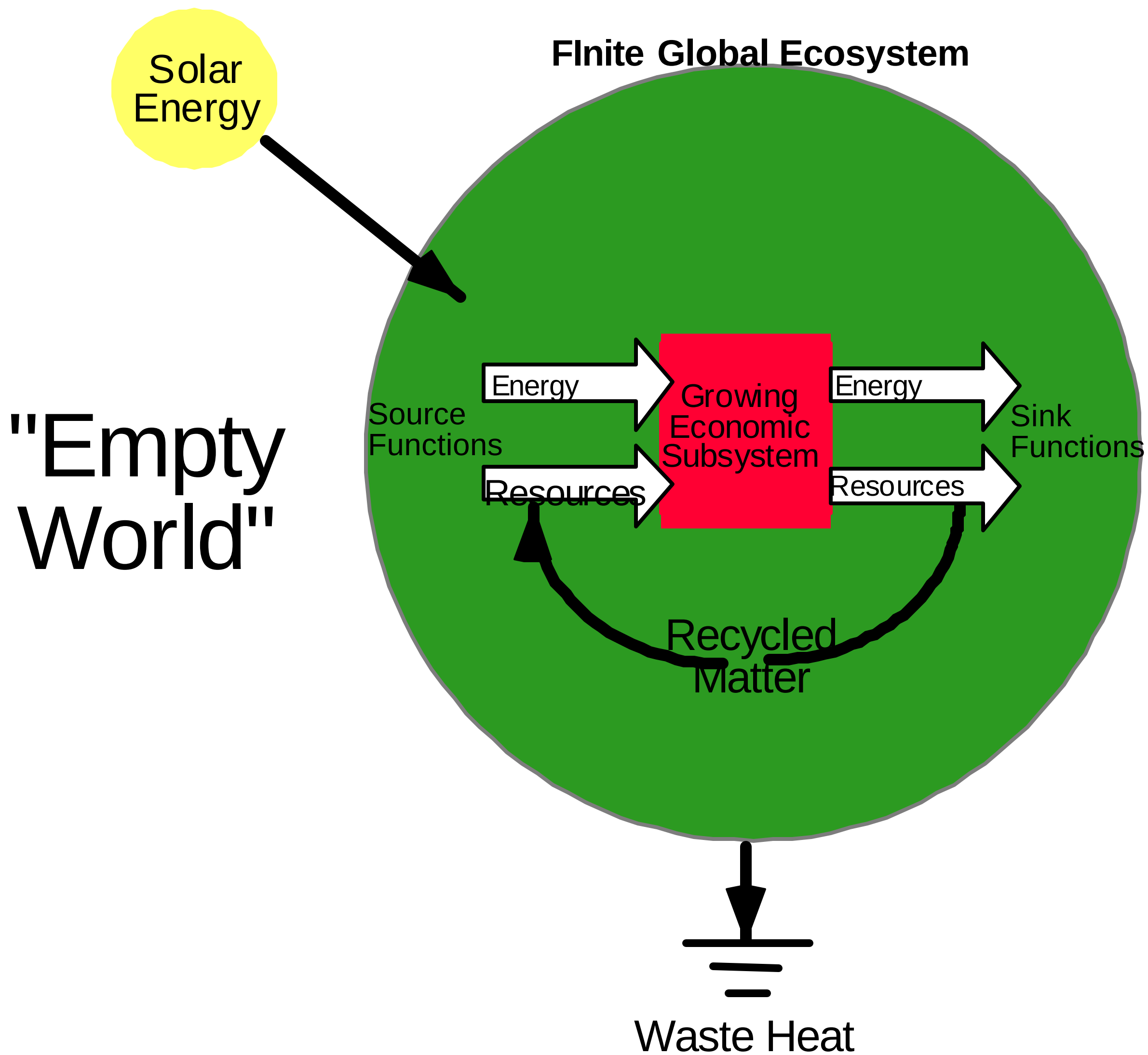
http://www.uvm.edu/giee



Practical Problem Solving
Requires the *Integration* of:

- Vision
  - a. How the world works
  - b. How we would like the world to be
- Tools and Analysis
  - appropriate to the vision
- Implementation
  - appropriate to the vision



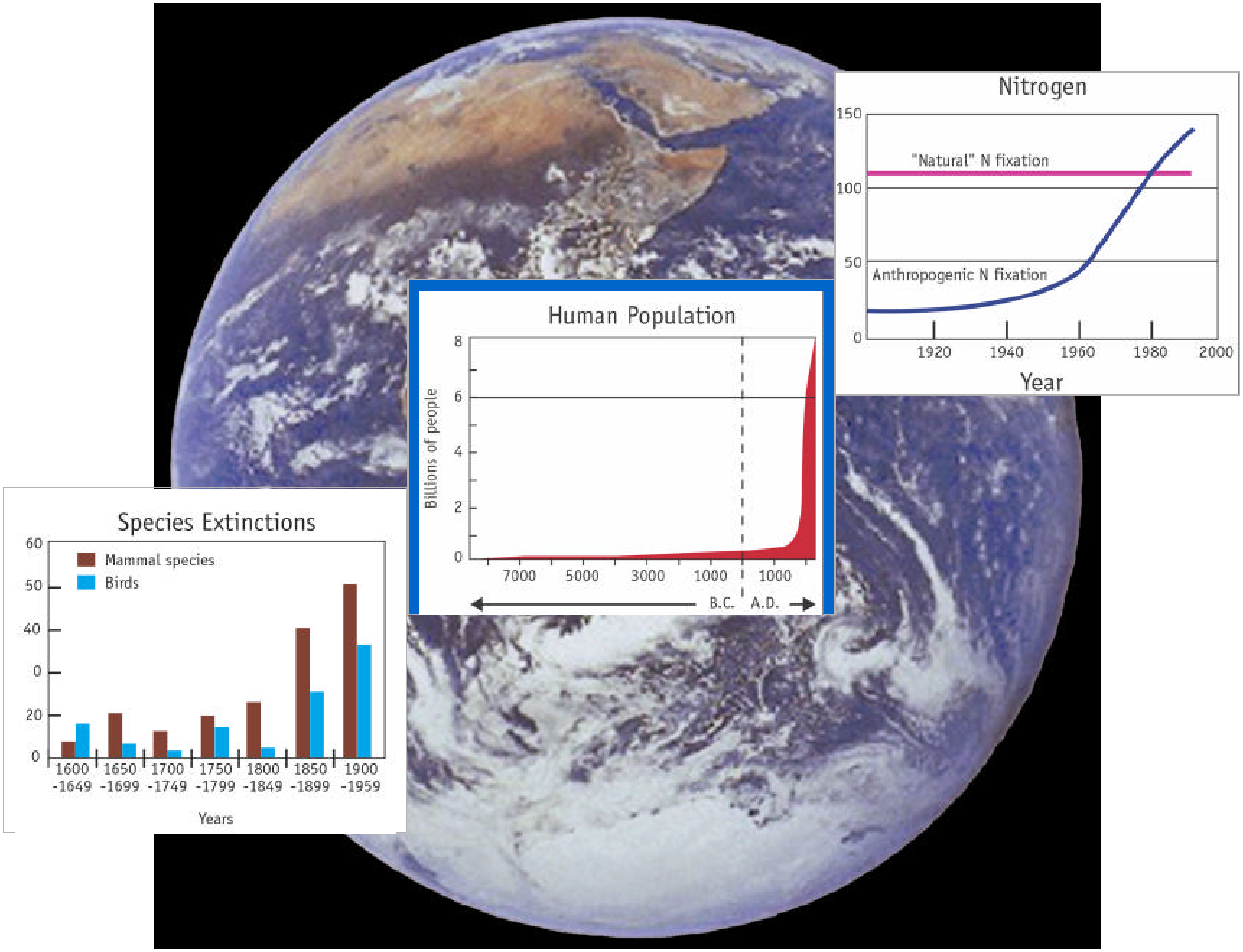

Solar Energy
FInite Global Ecosystem
"Empty World"
Energy
Source Functions
Resources
Growing Economic Subsystem
Energy
Sink Functions
Resources
Recycled Matter
Waste Heat

Anthroposphere

Marc Imhoff

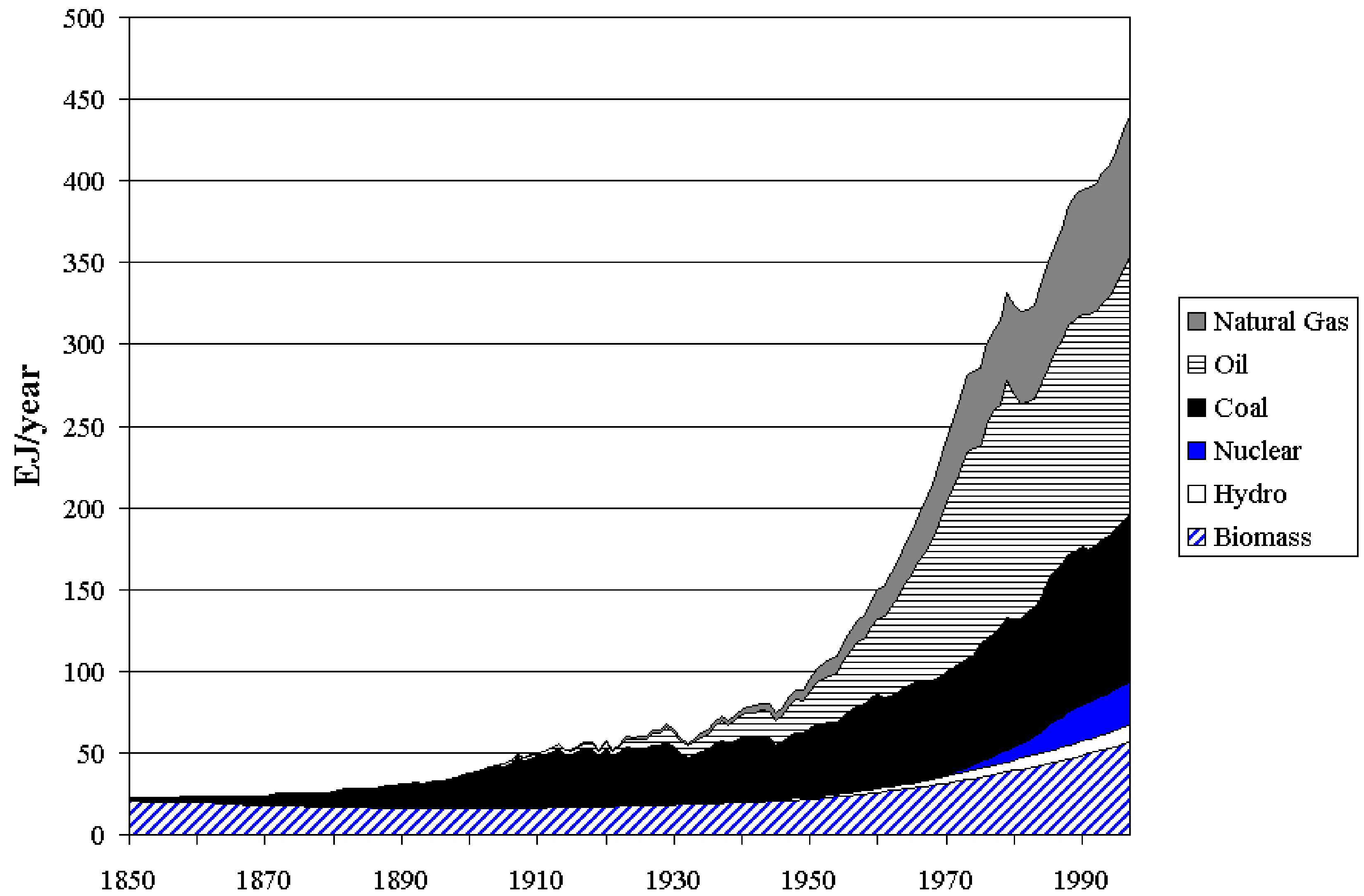
Biospheric Sciences Branch

NASA

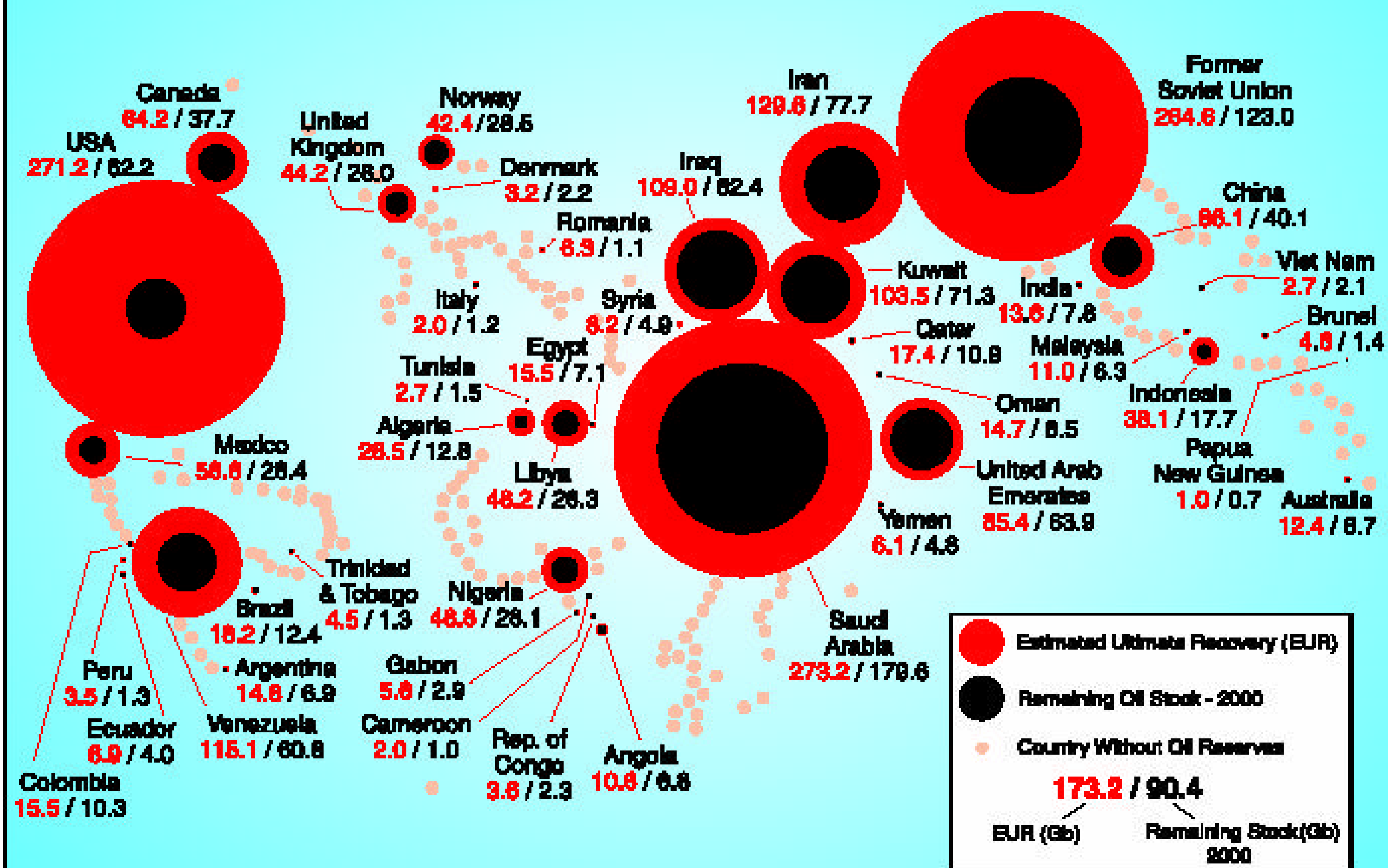


The Challenge: Sustainable Management of an Ever-Changing Planet

World Primary Energy Supply by Source, 1850-1997



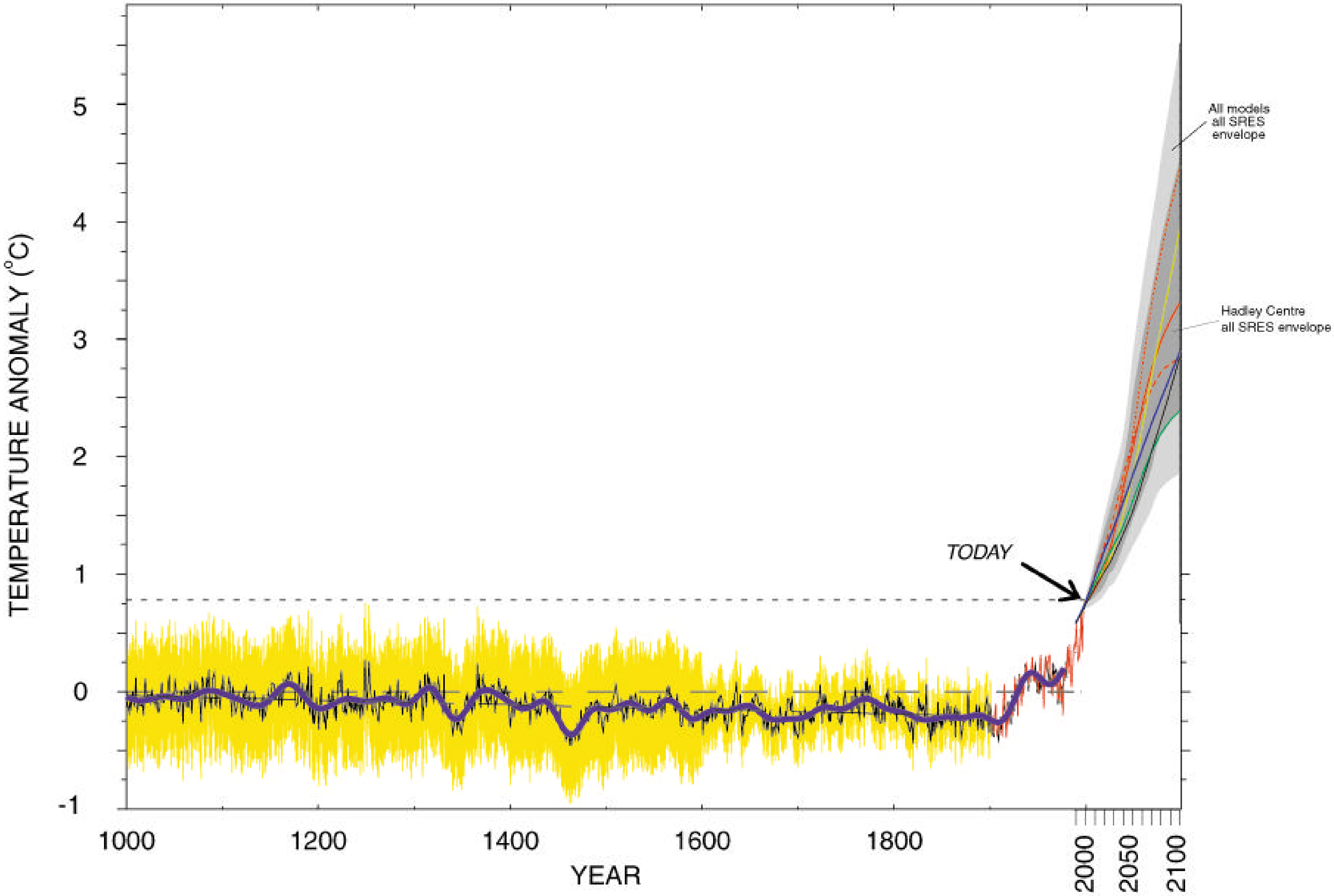
Estimated World Oil Ultimate Recovery (EUR) and Remaining Stocks - 2000

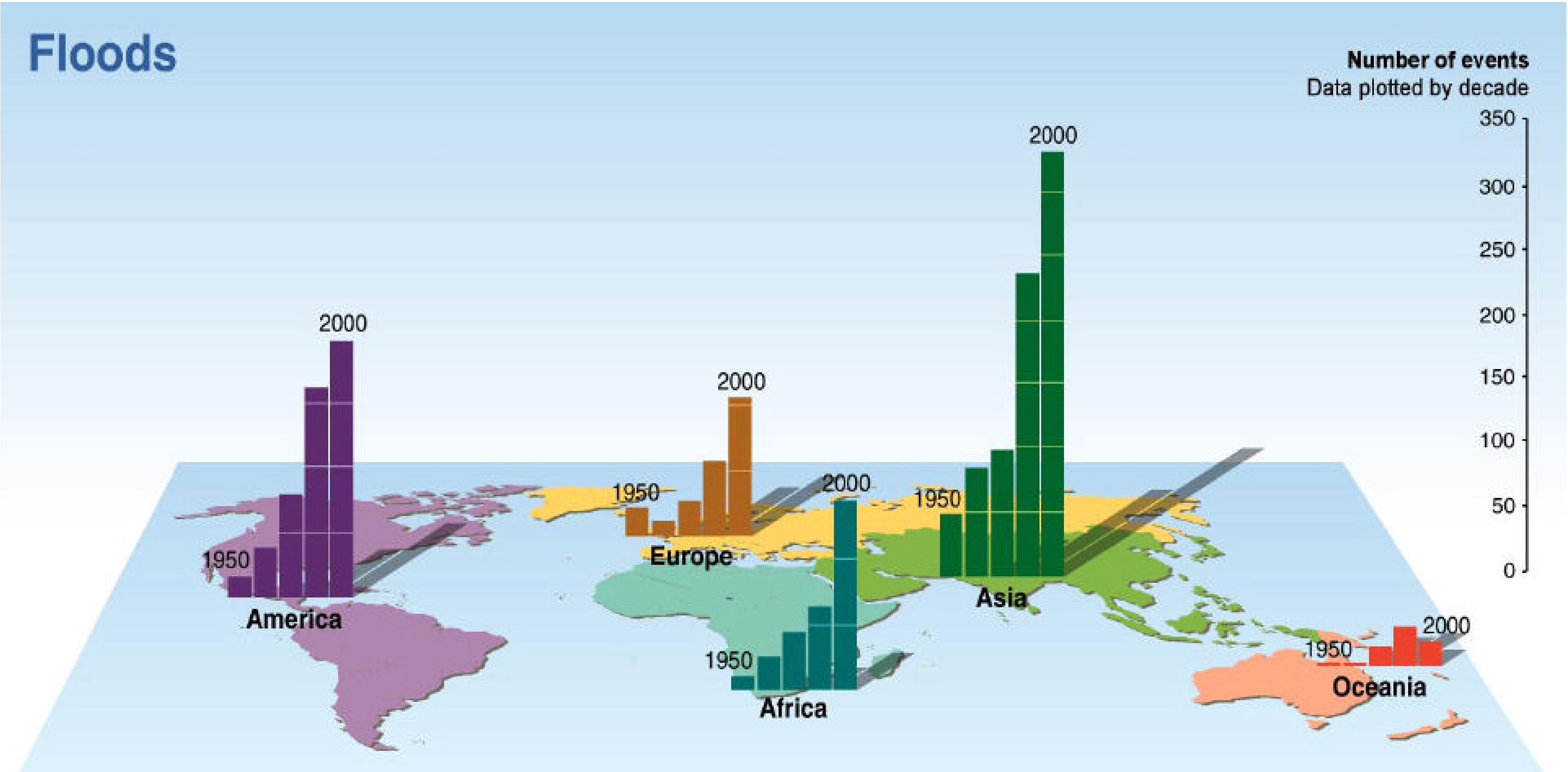


From: *The World Petroleum Life-Cycle*, Richard C. Duncan and Walter Youngquist, 1998

Atmosphere

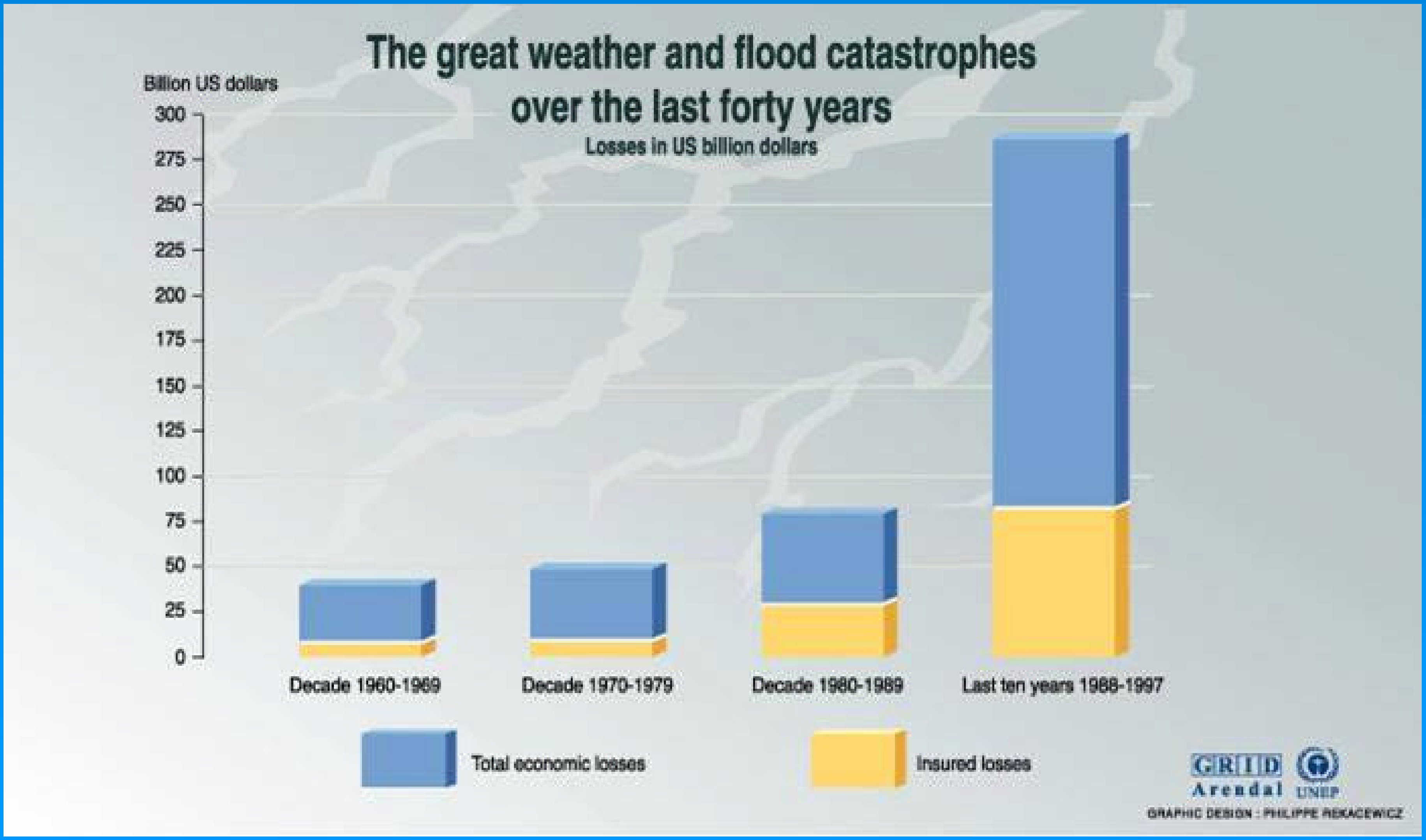
Temperature, past and future





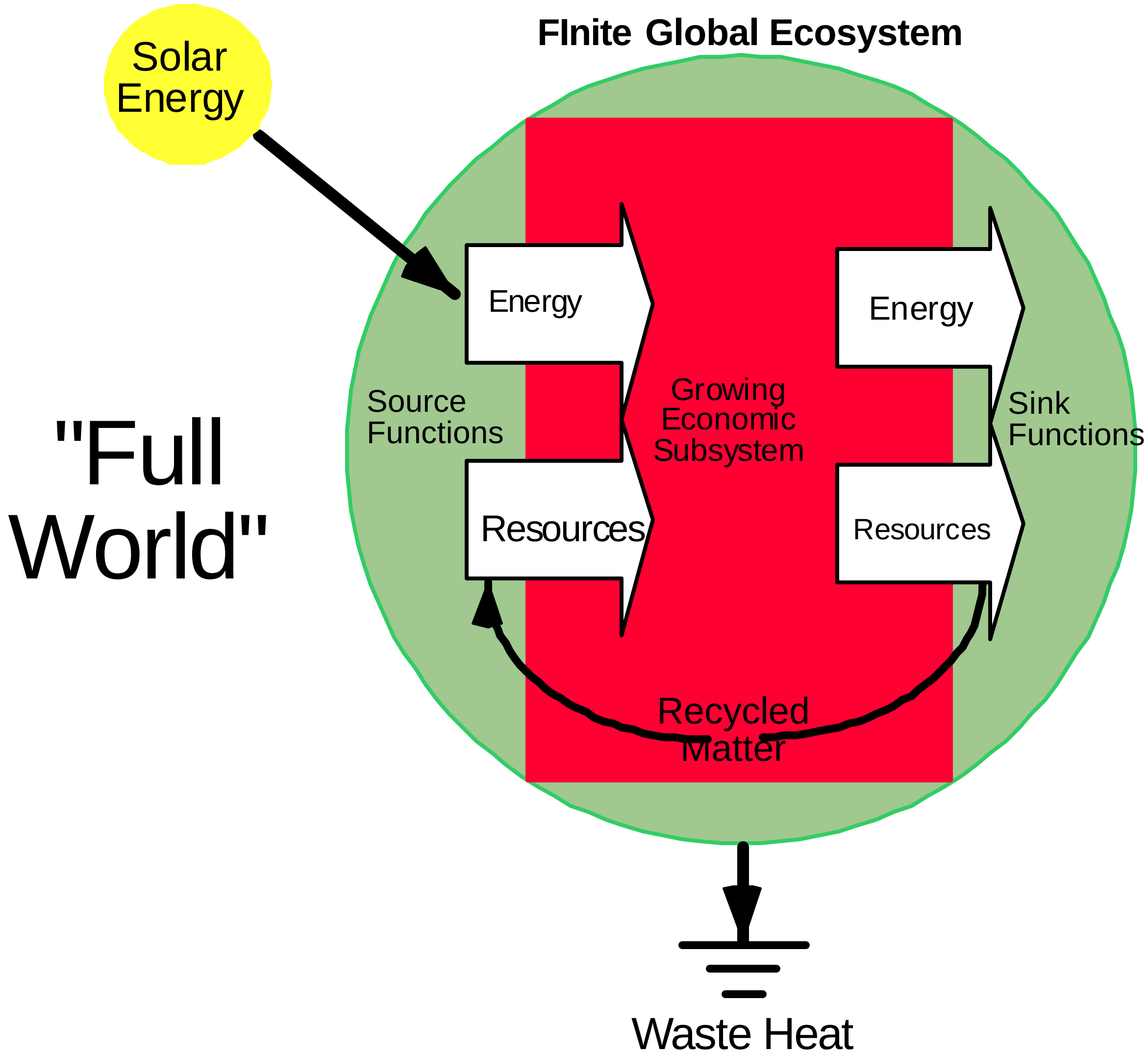
Source: Millennium Ecosystem Assessment

Weather-related economic damages have increased



Biosphere

Sea-viewing Wide Field-of-View Sensor (SeaWiFS)
data on marine and terrestrial plant productivity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Energy
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Resources
Resources
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Waste Heat

Ecological Economics

oikos = “house”
logy = “study or knowledge”
nomics = “management”

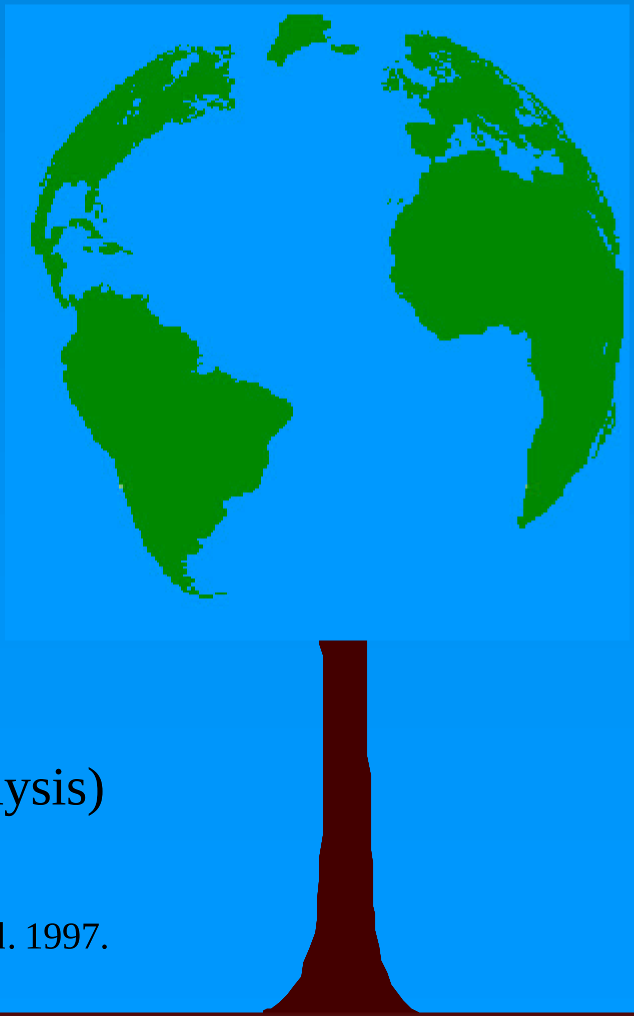
Literally: *management of the house (earth) based on study and knowledge of same*

Integrated Questions/Goals:

- Ecologically Sustainable **Scale**
- Socially Fair **Distribution**
- Economically Efficient **Allocation**

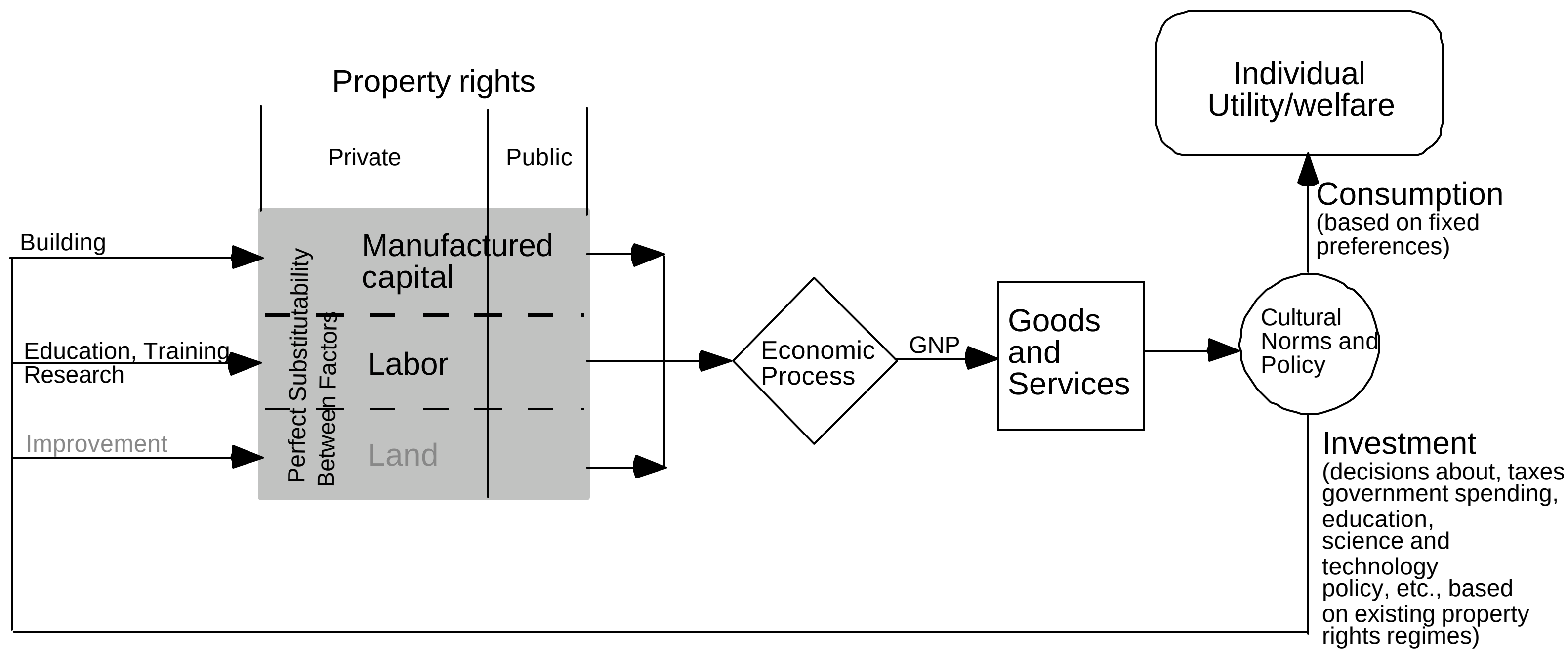
Methods:

- Transdisciplinary **Dialogue**
- **Problem** (rather than tools) **Focus**
- **Integrated Science** (balanced synthesis & analysis)
- Effective and adaptive **Institutions**



See: Costanza, R., J. C. Cumberland, H. E. Daly, R. Goodland, and R. Norgaard. 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, 275 pp.

”Empty World" Model of the Economy

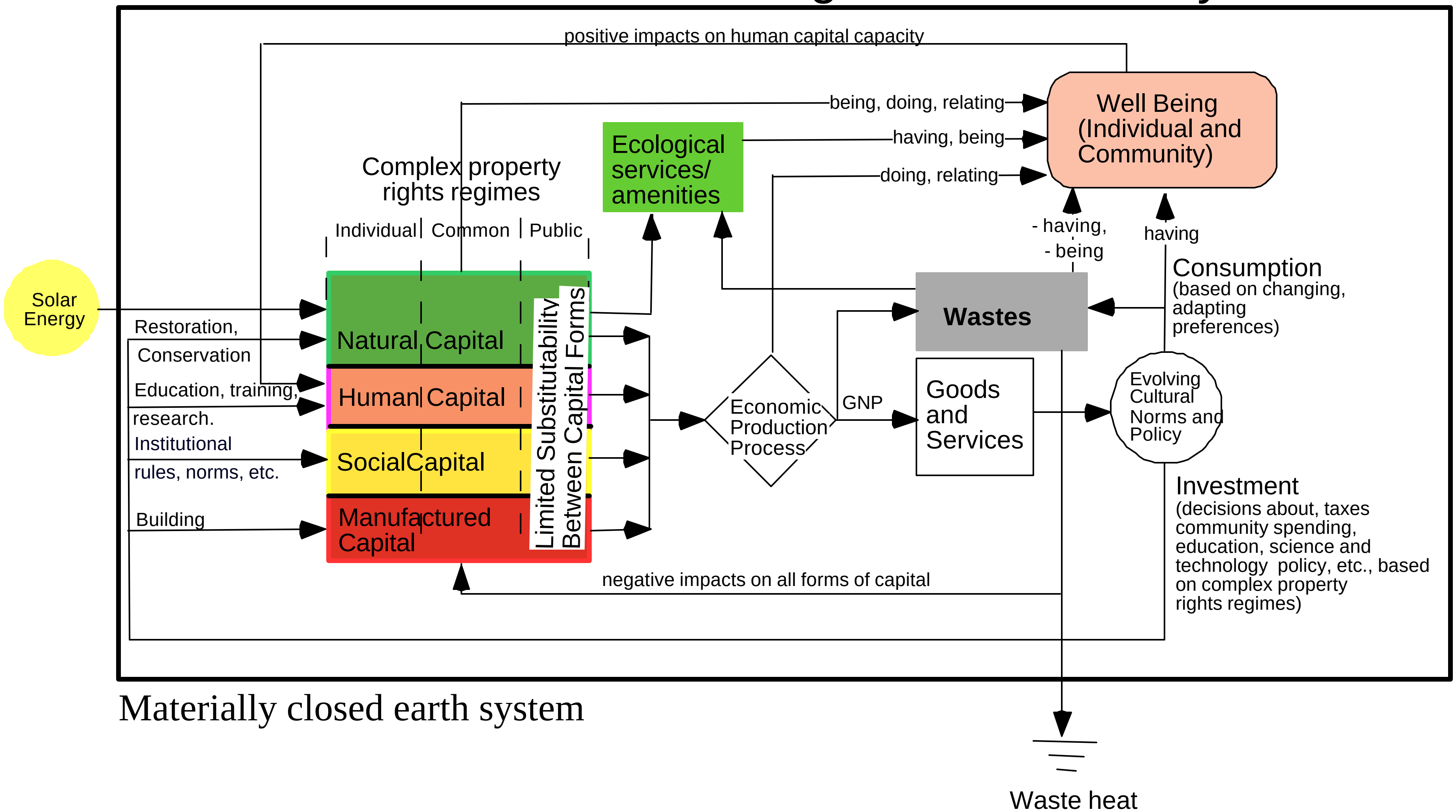


Perfect Substitutability

"The prevailing standard model of growth assumes that there are no limits on the feasibility of expanding the supplies of non-human agents of production. It is basically a two-factor model in which production depends only on labor and reproducible capital. Land and resources, the third member of the classical triad, have generally been dropped...the tacit justification has been that reproducible capital is a near perfect substitute for land and other exhaustible resources."

Nordhaus, W. and J. Tobin. 1972. Is Growth Obsolete? National Bureau of Economic Research, Columbia University Press, New York.

“Full World” Model of the Ecological Economic System



From: Costanza, R., J. C. Cumberland, H. E. Daly, R. Goodland, and R. Norgaard. 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, 275 pp.

Earth Shareholder's Report:

Beyond the Confrontational Debate on the Environment

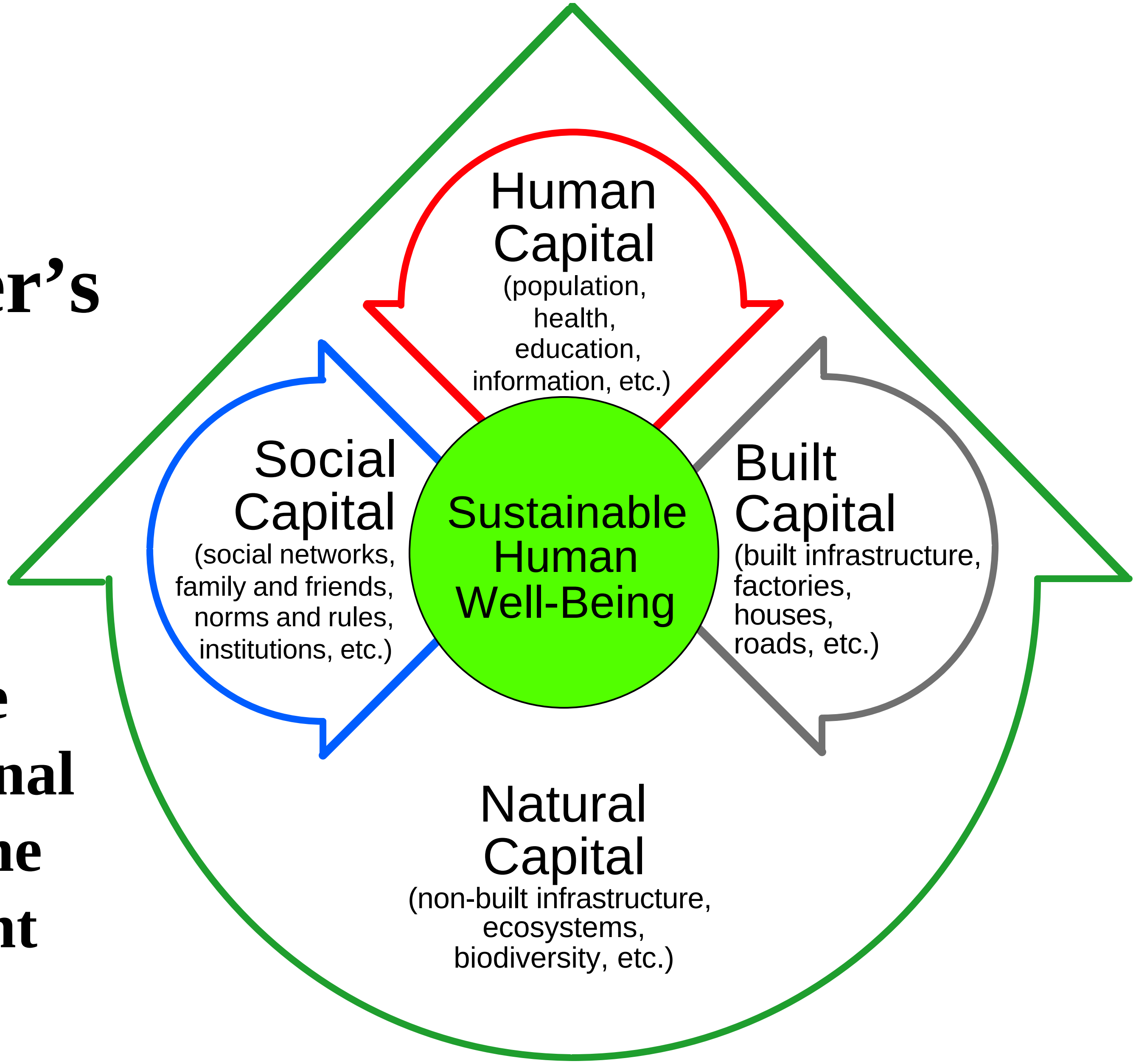
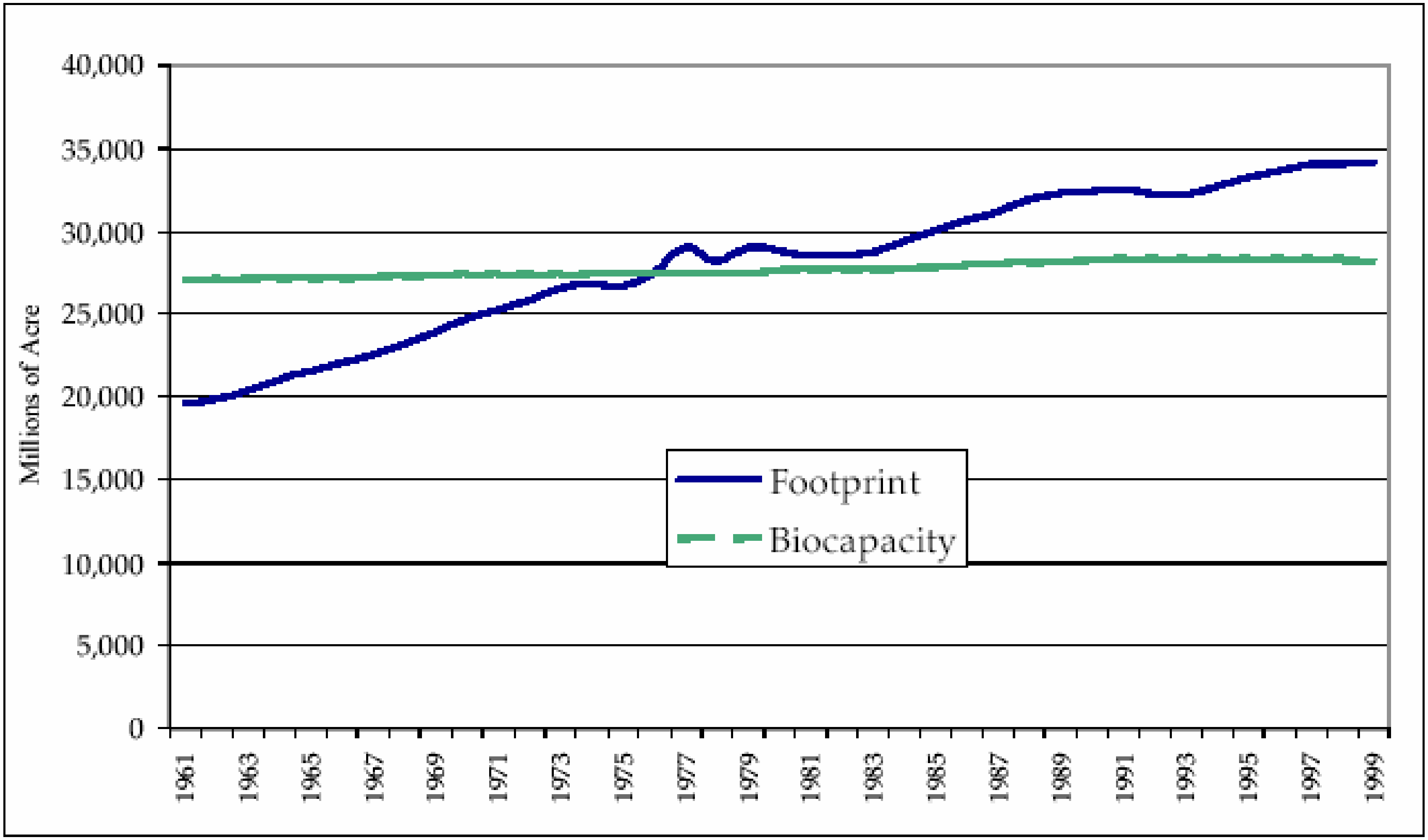


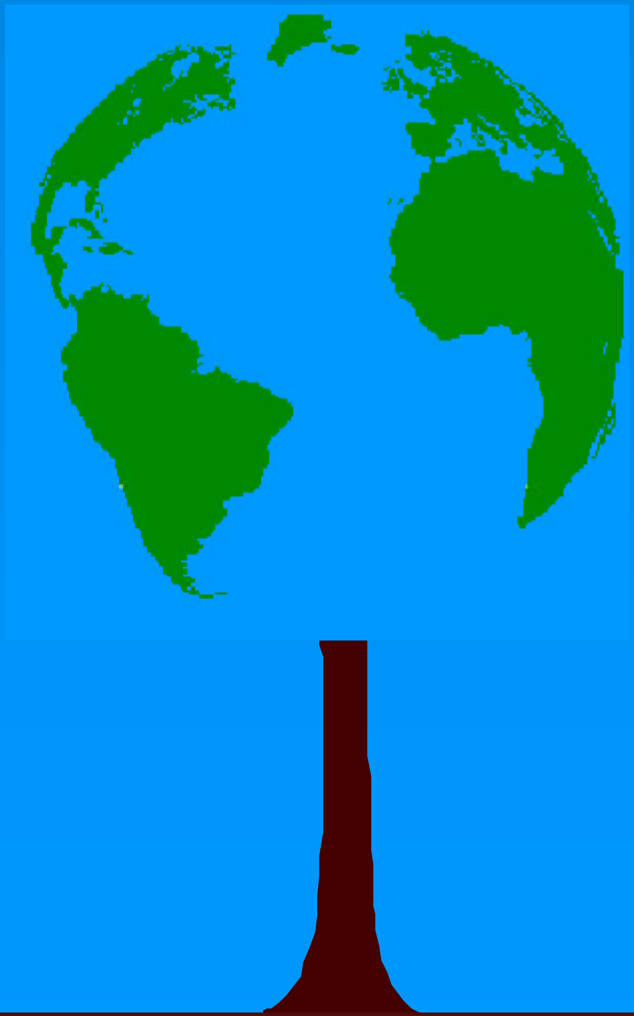
ILLUSTRATION 1:

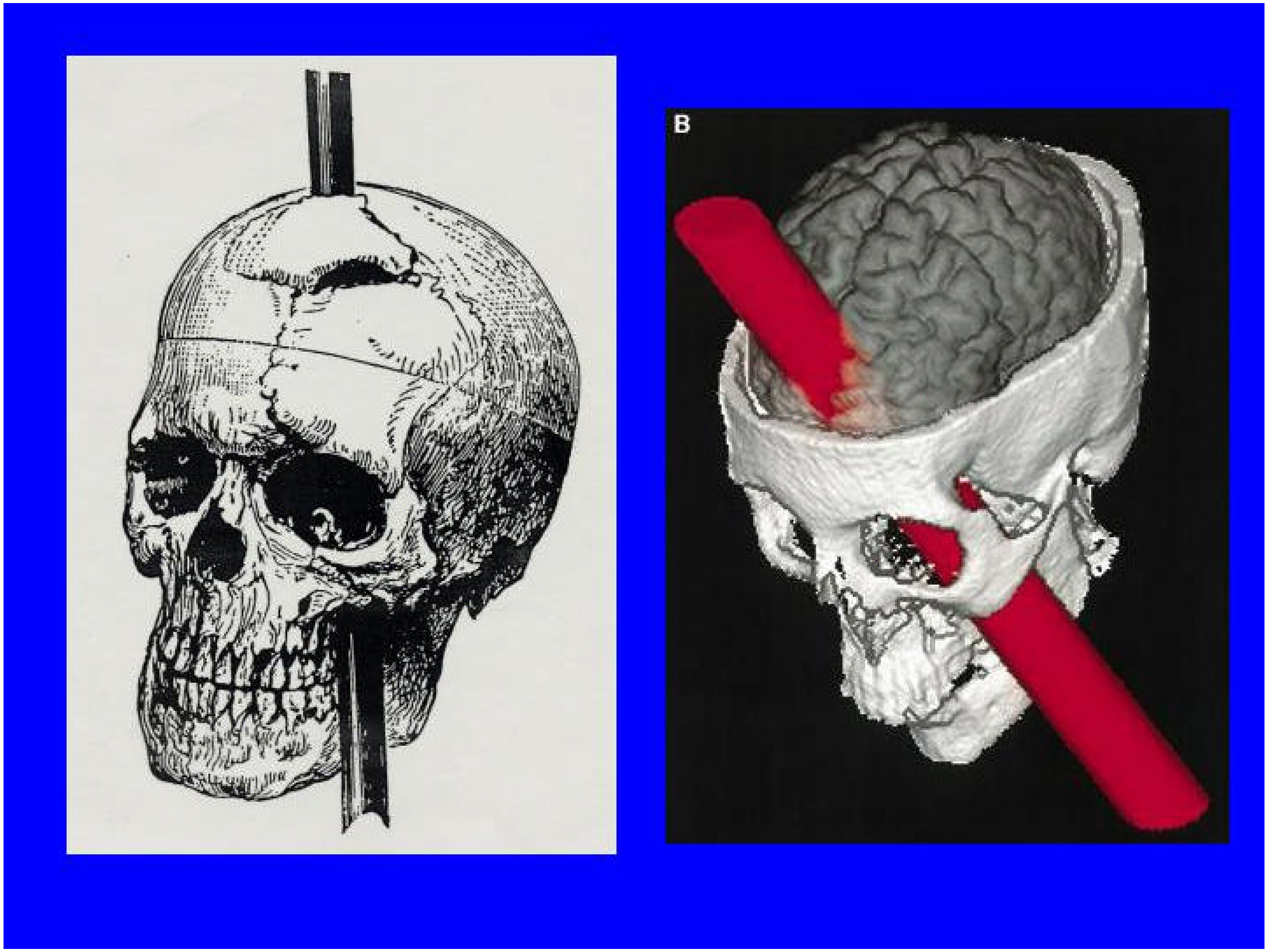
HUMANITY'S TOTAL FOOTPRINT 1961-2000



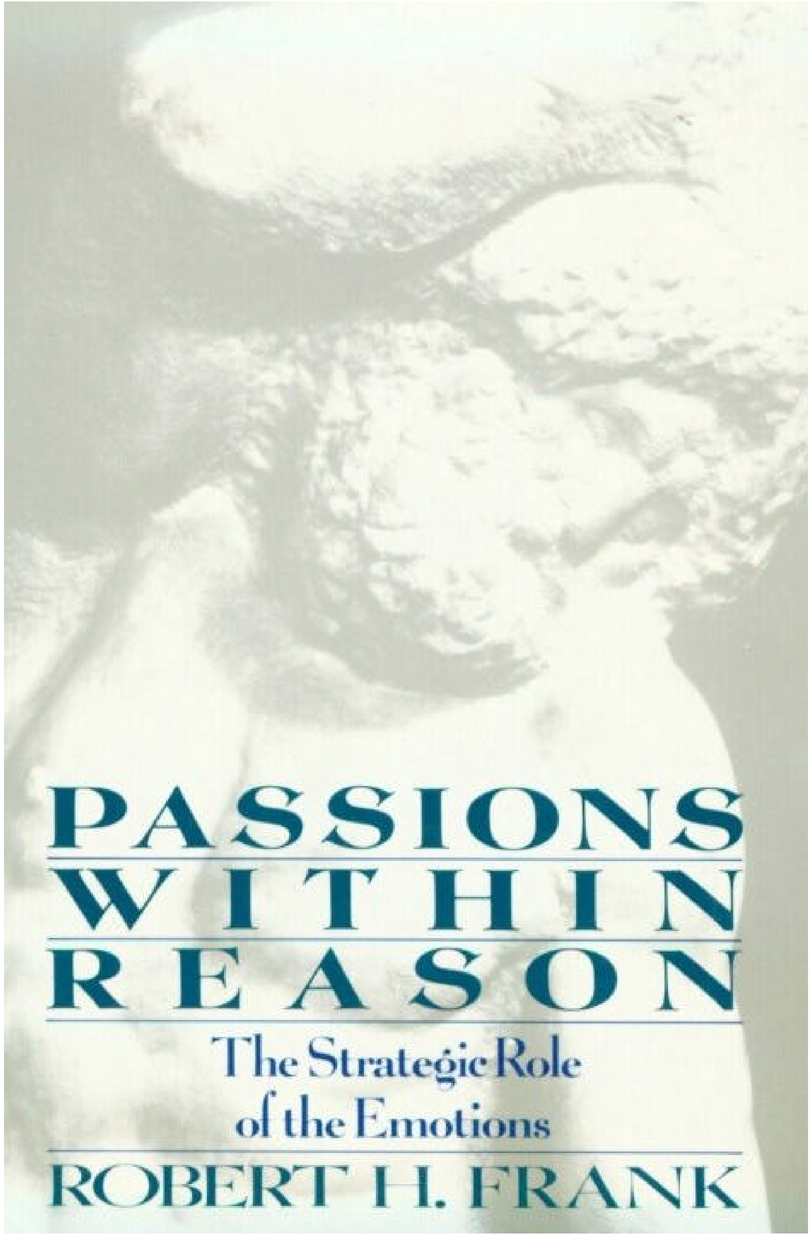
More realistic vision of human behavior

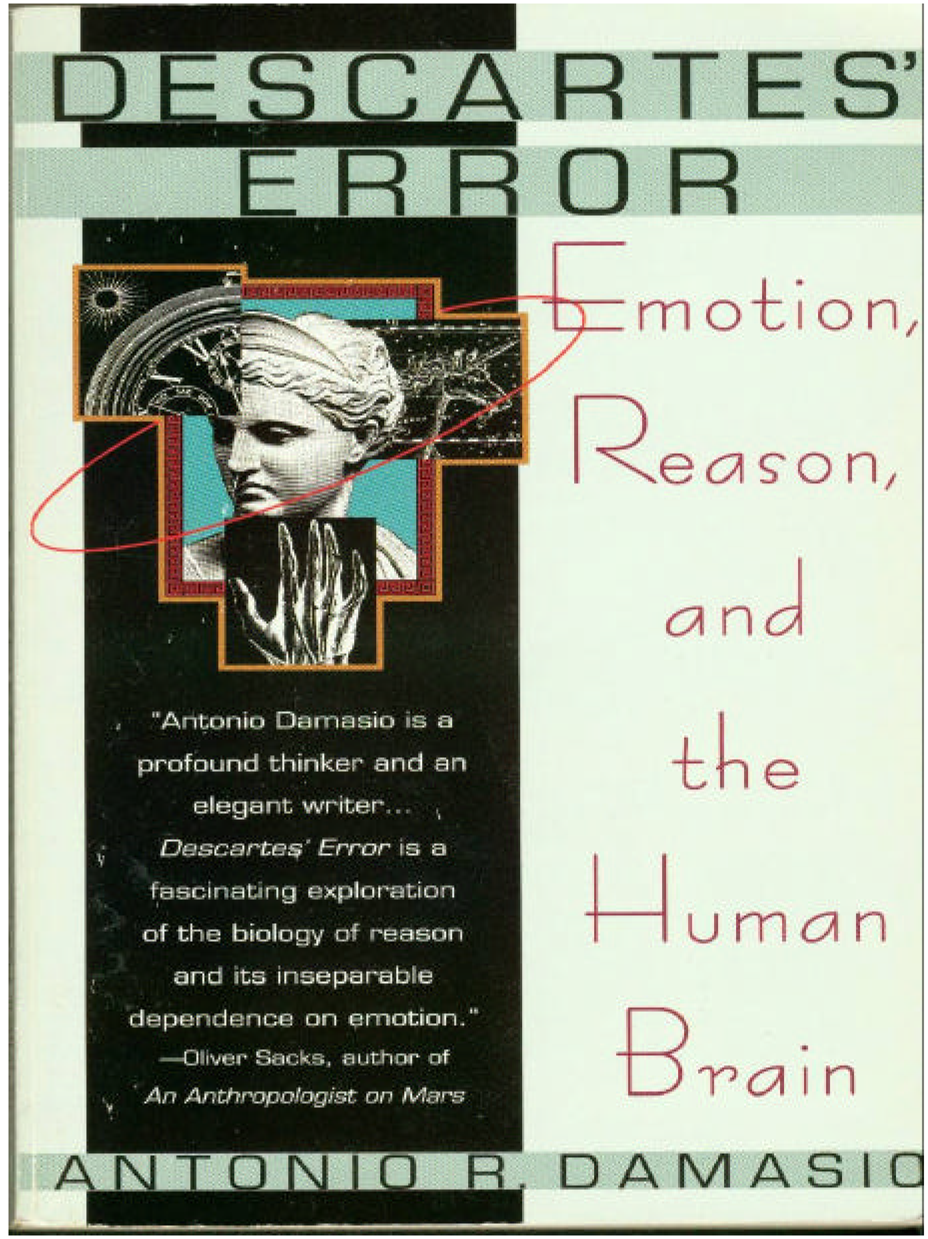
- Multiple motivations (personality types, culture, etc.)
- Limited knowledge and "rationality"
- Evolving preferences
- Satisfaction based on relative, rather than absolute, consumption, plus a host of "non-consumption" factors
- Central role of emotions in decision-making and evading social traps
- Embedded in multiscale, complex, adaptive, systems





Phineas Gage





We devote a huge chunk of our brains to recognizing faces and reading other people's emotions and intentions. This is essential to allow social capital to form and to build rules and norms that can avoid free rider problems and other social traps.

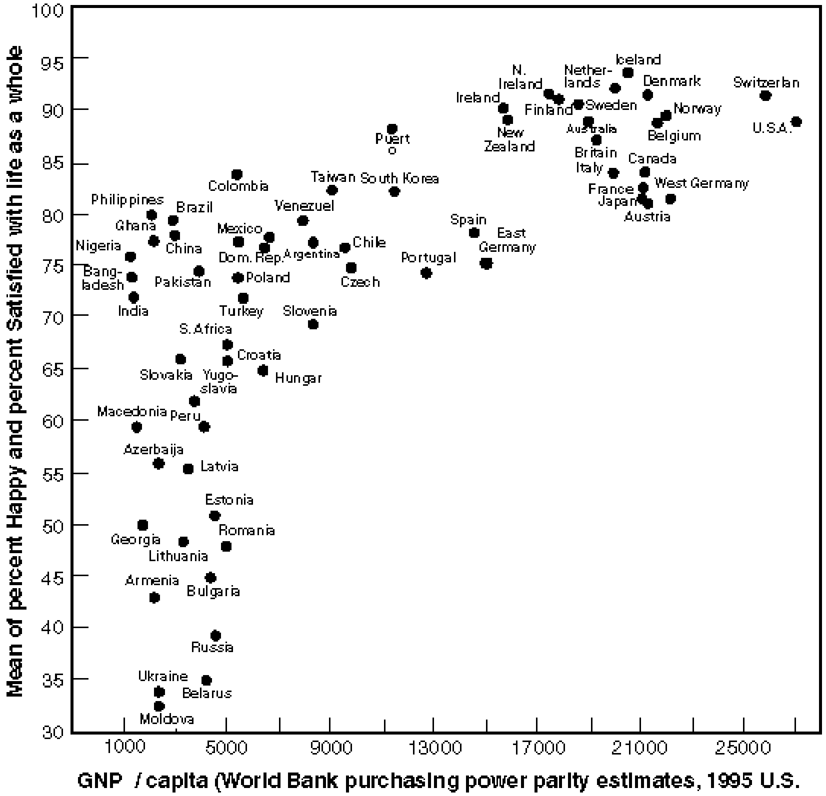
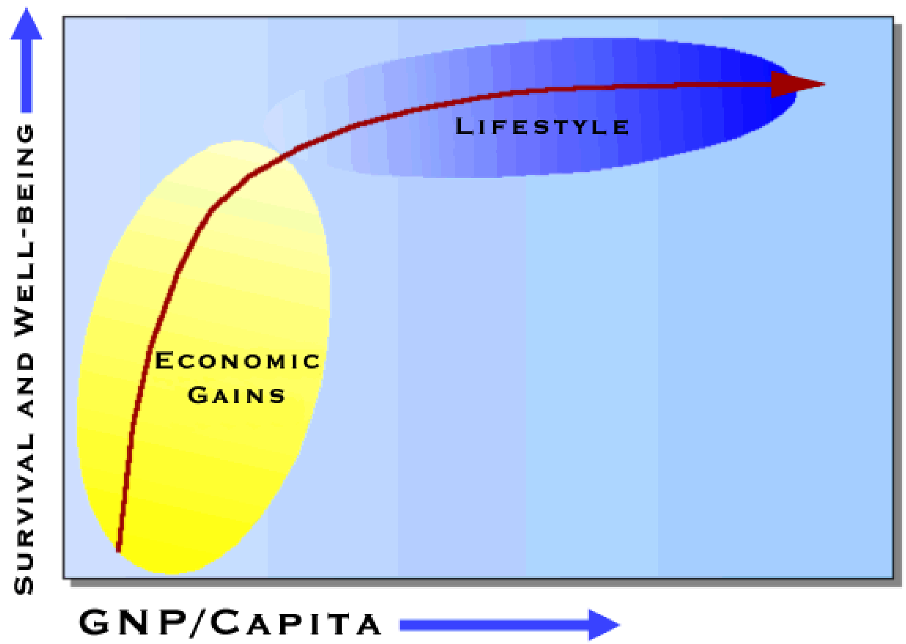
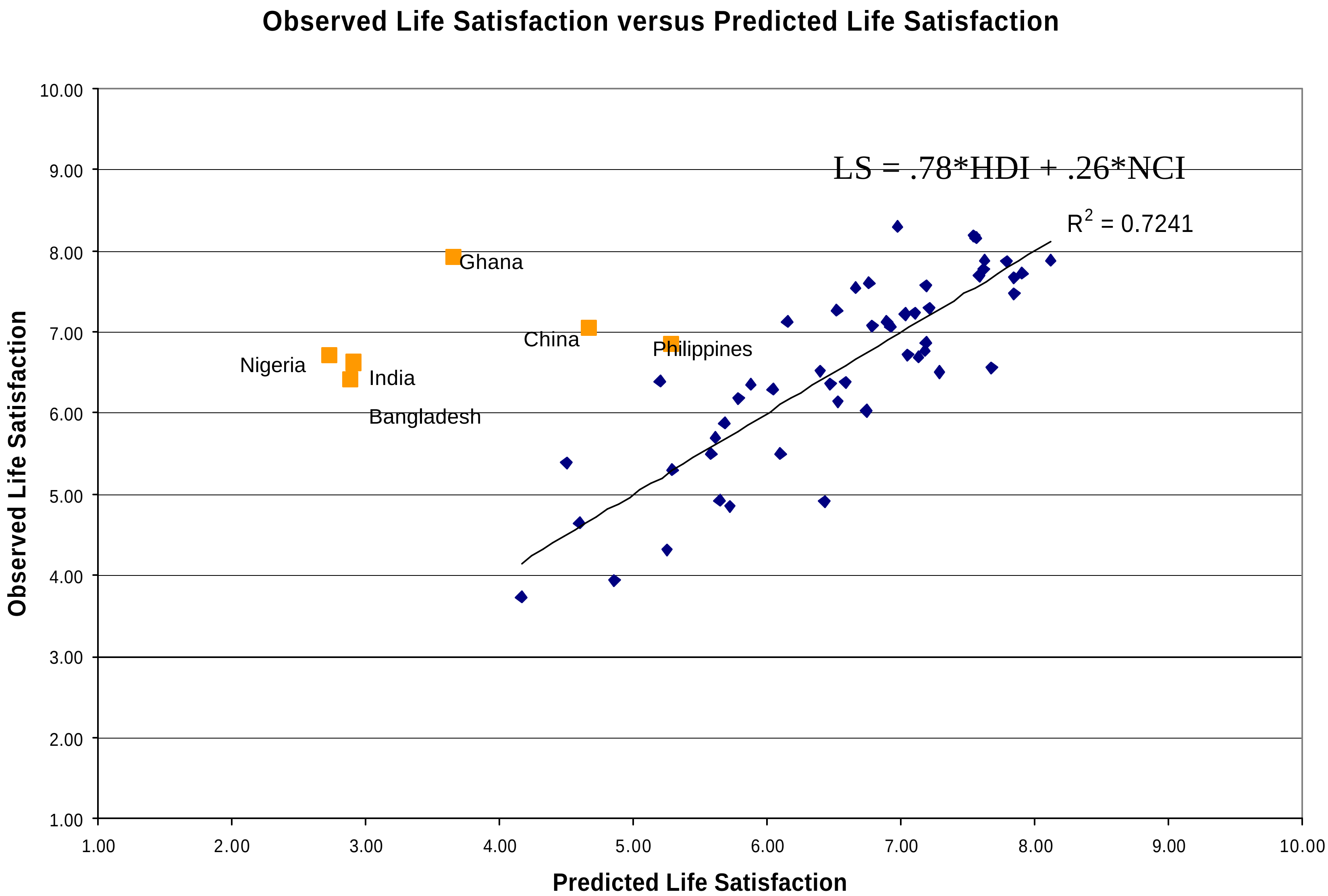


Figure 2. Subjective well-being by level of economic development.
Source: World Values Surveys; GNP/capita purchasing power estimates from World Bank, World Development Report, 1997.
R = .70 N = 65 p < .0000

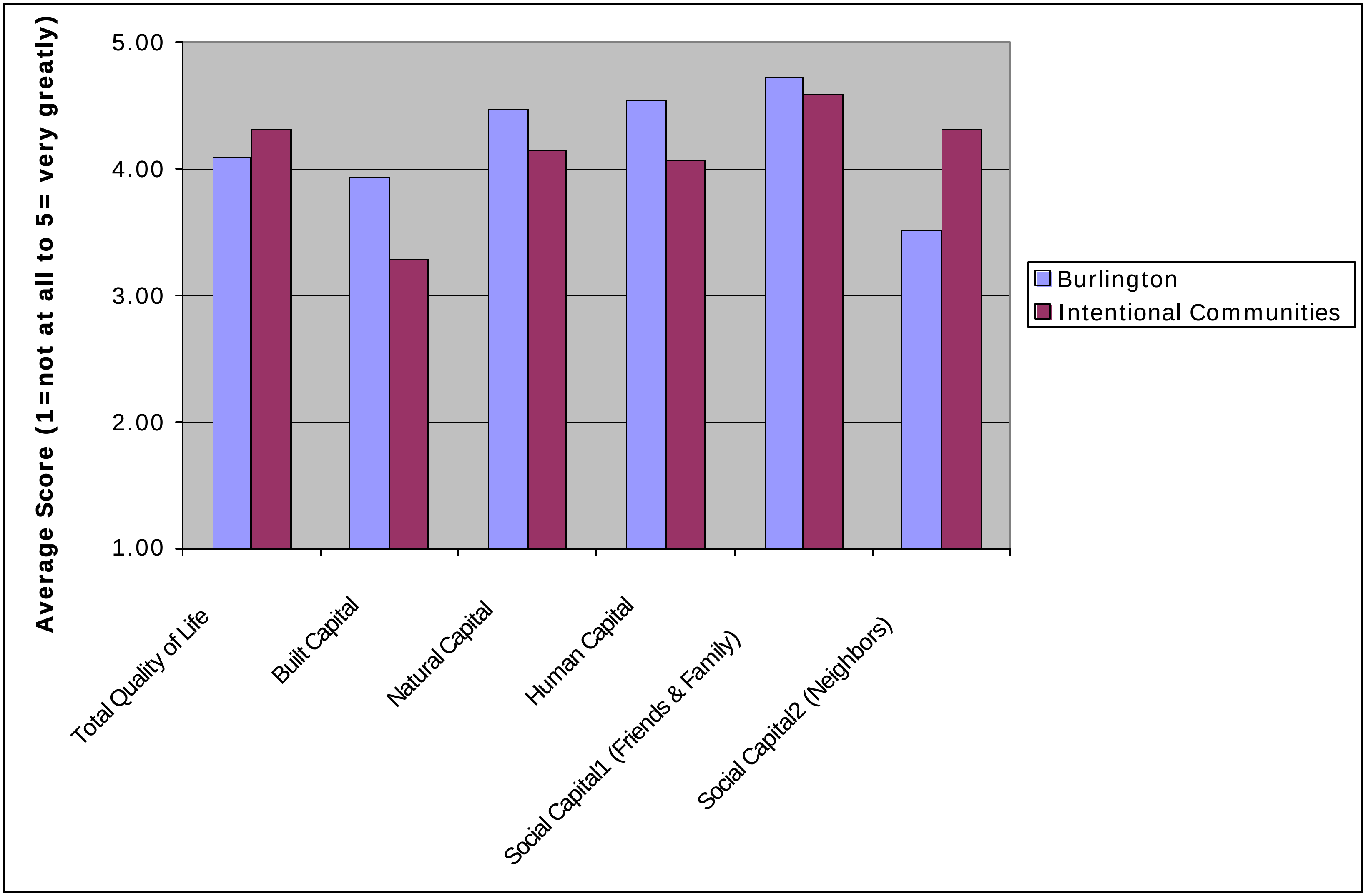


Source: R Ingelhart, 1997



Predicted Life Satisfaction (LS)

From: Vemuri, A. W. and R. Costanza. 2005. The Role of Human, Social, Built, and Natural Capital in Explaining Life Satisfaction at the Country Level: Toward a National Well-Being Index (NWI). *Ecological Economics* (in press).



From: Mulder, K., R. Costanza, and J. Erickson. The contribution of built, human, social and natural capital to quality of life in intentional and unintentional communities. In review for *Ecological Economics*

A range of goals for national accounting and their corresponding frameworks, measures, and valuation methods

Goal	Economic Income — Marketed	**Economic Income** — Weak Sustainability	Economic Income — Strong Sustainability	**Economic Welfare**	**Human Welfare**
Basic Framework	value of marketed goods and services produced and consumed in an economy	1 + non-marketed goods and services consumption	2 + preserve essential natural capital	value of the wefare effects of income and other factors (including distribution, household work, loss of natural capital etc.)	assessment of the degree to which human needs are fulfilled
Non-environmentally adjusted measures	**GNP** (Gross National Product) **GDP** (Gross Domestic Product) **NNP** (Net National Product)			**MEW** (Measure of Economic Welfare)	**HDI** (Human Development Index)
Environmentally adjusted measures	**NNP'** (Net National Product including non-produced assets)	**ENNP** (Environmental Net National Product) **SEEA** (System of Environmental Economic Accounts)	**SNI** (Sustainable National Income) **SEEA** (System of Environmental Economic Accounts)	**ISEW** (Index of Sustainable Economic Welfare)	**HNA** (Human Needs Assessment)
Appropriate Valuation Methods	Market values	1 + Willingness to Pay Based Values (see Table 2)	2 + Replacement Costs,+ Production Values	3 + Constructed Preferences	4 + Consensus Building Dialogue

From: Costanza, R., S. Farber, B. Castaneda and M. Grasso. 2001. Green national accounting: goals and methods. Pp. 262-282 in: Cleveland, C. J., D. I. Stern and R. Costanza (eds.) The economics of nature and the nature of economics. Edward Elgar Publishing, Cheltenham, England

The gross national product does not allow for the health of our children, the quality of their education, or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages; the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage ; neither our wisdom nor our learning; neither our compassion nor our devotion to our country; it measures everything, in short, except that which makes life worthwhile.

Robert F. Kennedy, 1968

Some would blame our current problems on an organized conspiracy. I wish it were so simple. Members of a conspiracy can be rooted out and brought to justice. This system, however, is fueled by something far more dangerous than conspiracy. It is driven not by a small band of men but by a concept that has become accepted as gospel: the idea that all economic growth benefits humankind and that the greater the growth, the more widespread the benefits.

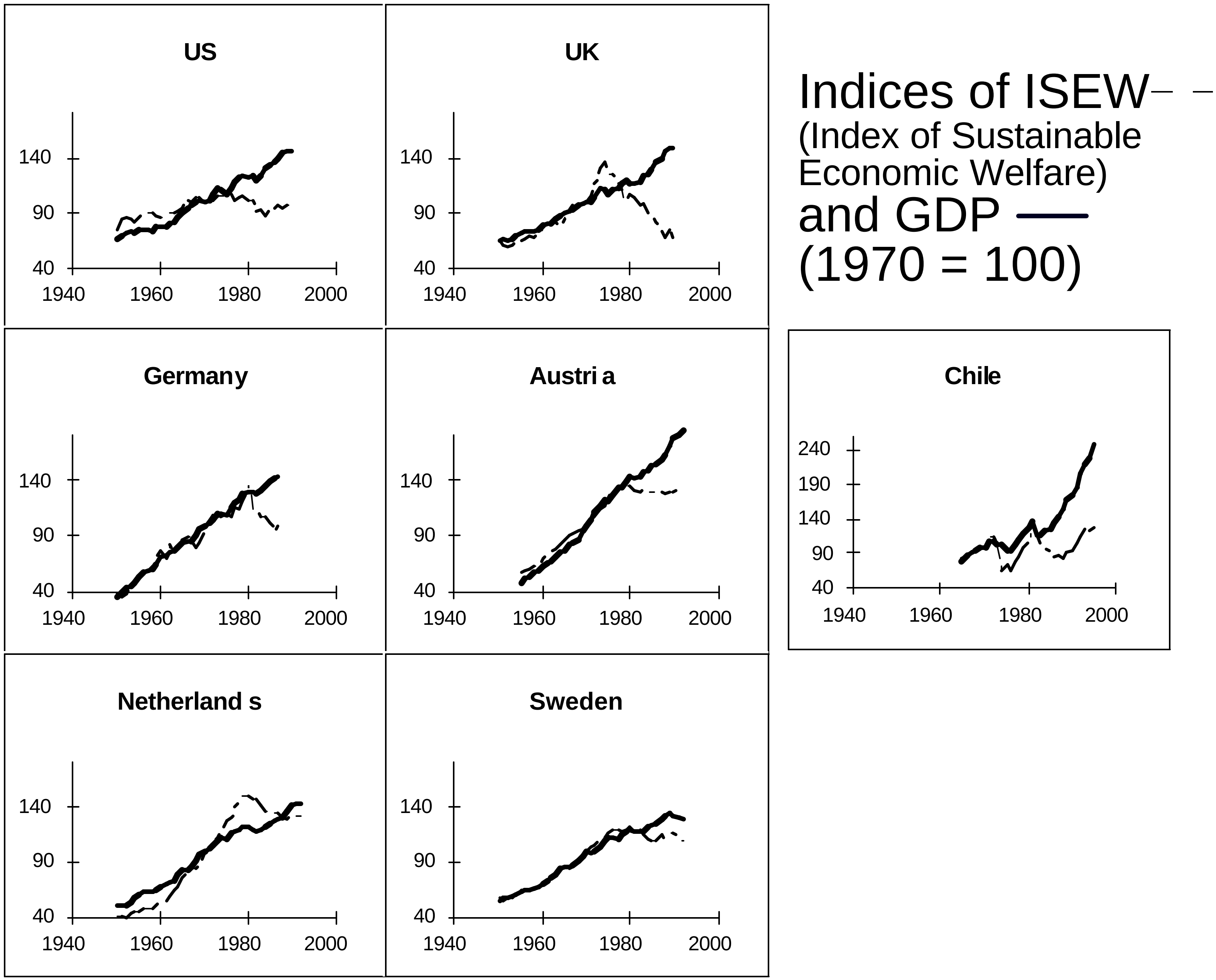
John Perkins, Confessions of an Economic Hit Man, 2004

GDP measures marketed economic activity, not welfare
ISEW (Index of Sustainable Economic Welfare) or
GPI (Genuine Progress Indicator) are intended to be better approximations to economic welfare, since they adjust for:

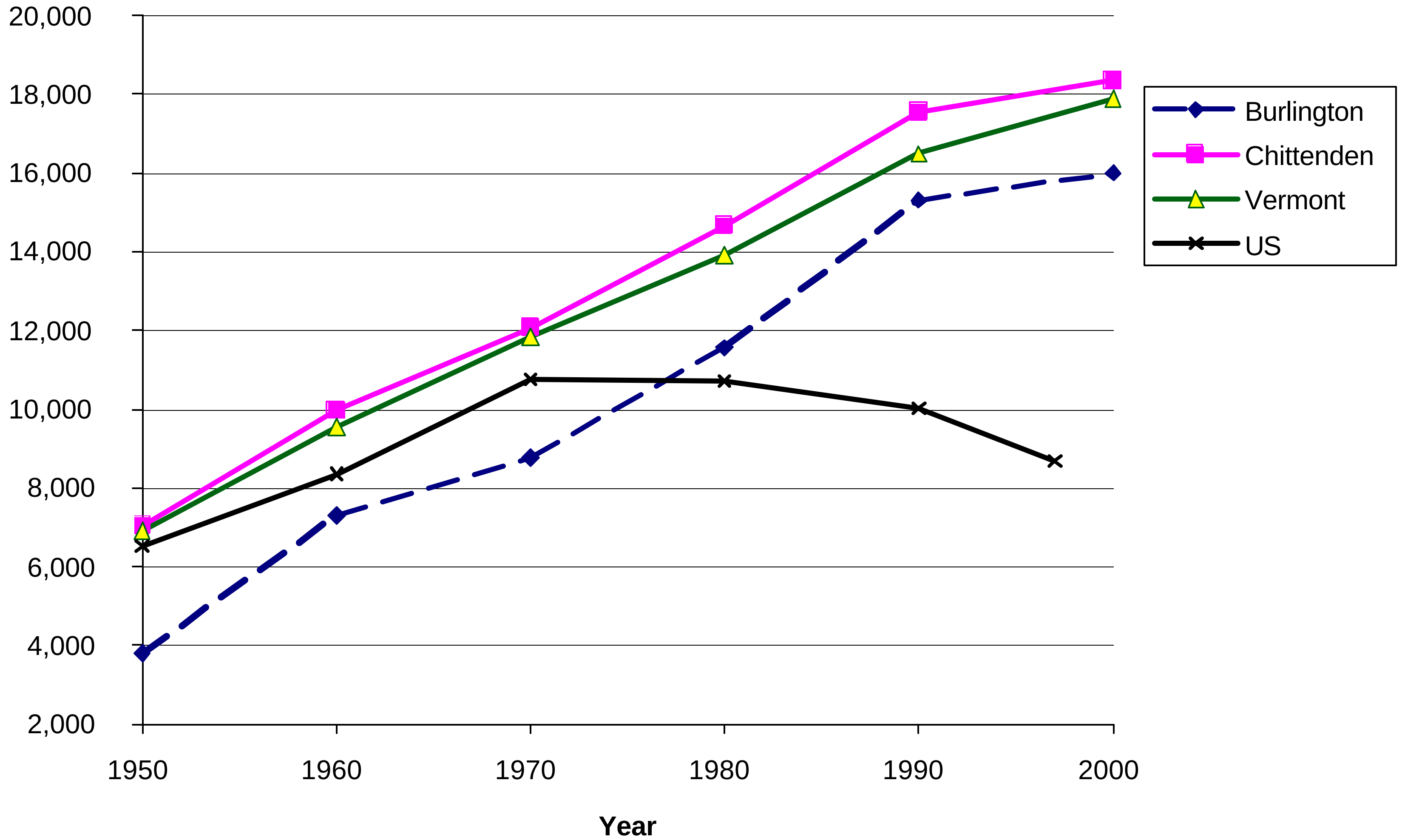
- Income distribution
- Value of Social Capital
- Value of Natural Capital
- Value of Non-Marketed Household Work
- and other things…

ISEW (or GPI) by Column

Column A: Personal Consumption Expenditures
Column B: Income Distribution
Column C: Personal Consumption Adjusted for Income Inequality
Column D: Value of Household Labor
Column E: Value of Volunteer Work
Column F: Services of Household Capital
Column G: Services Highways and Street
Column H: Cost of Crime
Column I: Cost of Family Breakdown
Column J: Loss of Leisure Time
Column K: Cost of Underemployment
Column L: Cost of Consumer Durables
Column M: Cost of Commuting
Column N: Cost of Household Pollution Abatement
Column O: Cost of Automobile Accidents
Column P: Cost of Water Pollution
Column Q: Cost of Air Pollution
Column R: Cost of Noise Pollution
Column S: Loss of Wetlands
Column T: Loss of Farmland
Column U: Depletion of Nonrenewable Resources
Column V: Long-Term Environmental Damage
Column W: Cost of Ozone Depletion
Column X: Loss of Forest Cover
Column Y: Net Capital Investment
Column Z: Net Foreign Lending and Borrowing


US
UK
Germany
Austri a
Chile
Netherland s
Sweden
140
90
40
240
190
1940
1960
1980
2000
Indices of ISEW
(Index of Sustainable
Economic Welfare)
and GDP
(1970 = 100)

Genuine Progress Indicator (GPI) per capita

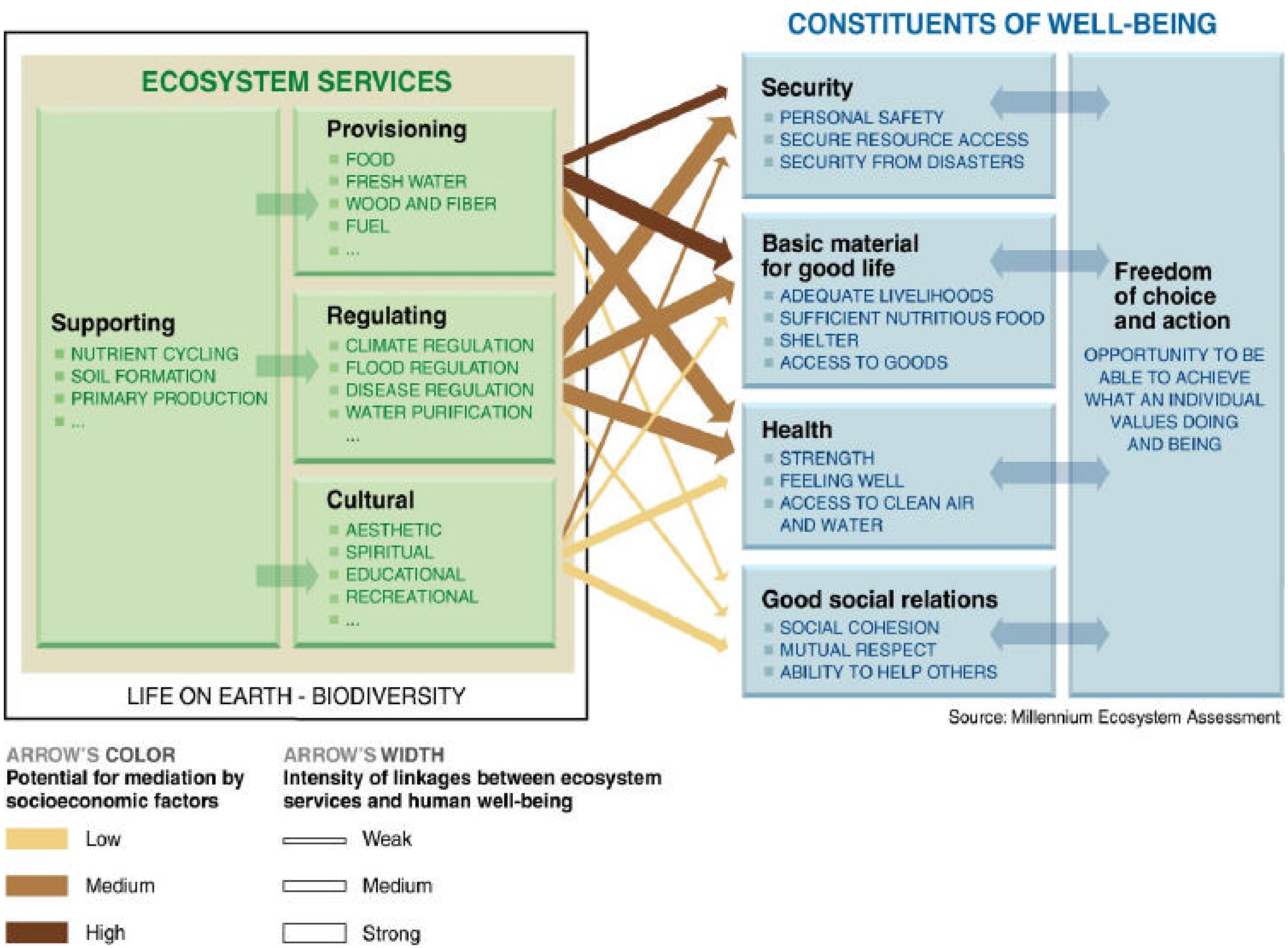


From: Costanza, R. J. Erickson, K. Fligger, A. Adams, C. Adams, B. Altschuler, S. Balter, B. Fisher, J. Hike, J. Kelly, T. Kerr, M. McCauley, K. Montone, M. Rauch, K. Schmiedeskamp, D. Saxton, L. Sparacino, W. Tusinski, and L. Williams. 2004. Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County, and Burlington, from 1950 to 2000. *Ecological Economics* 51: 139-155

ECOSYSTEM SERVICES	ECOSYSTEM FUNCTIONS
Gas regulation	Regulation of atmospheric chemical composition.
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global, regional, or local levels.
Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.
Water regulation	Regulation of hydrological flows.
Water supply	Storage and retention of water.
Erosion control and sediment retention	Retention of soil within an ecosystem.
Soil formation	Soil formation processes.
Nutrient cycling	Storage, internal cycling, processing, and acquisition of nutrients.
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.
Pollination	Movement of floral gametes.
Biological control	Trophic-dynamic regulations of populations.
Refugia	Habitat for resident and transient populations.
Food production	That portion of gross primary production extractable as food.
Raw materials	That portion of gross primary production extractable as raw materials.
Genetic resources	Sources of unique biological materials and products.
Recreation	Providing opportunities for recreational activities.
Cultural	Providing opportunities for non-commercial uses.

From: Costanza, R. R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R.V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387:253-260

Focus: Consequences of Ecosystem Change for Human Well-being



Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R.V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt. 1997. **The value of the world's ecosystem services and natural capital.** *Nature* 387:253-260.

2nd most highly cited article in the last 10 years in the Ecology/Environment area according to the ISI Web of Science.

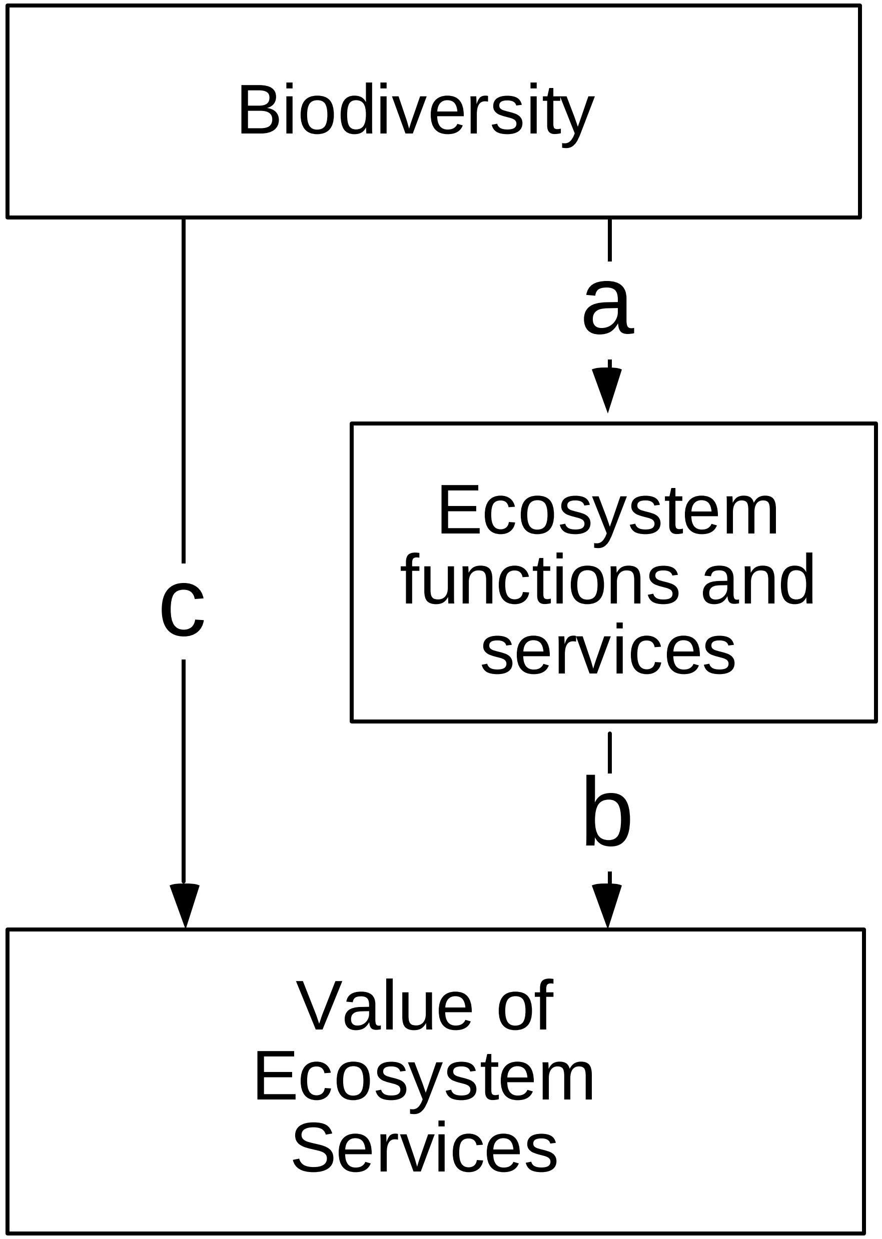
Summary of global values of annual ecosystem services (From: Costanza et al. 1997)

Biome	Area (e6 ha)	Value per ha ($/ha/yr)	Global Flow Value (e12 $/yr)
Marine	**36,302**	**577**	**20.9**
Open Ocean	33,200	252	8.4
Coastal	3,102	4052	12.6
Estuaries	180	22832	4.1
Seagrass/Algae Beds	200	19004	3.8
Coral Reefs	62	6075	0.3
Shelf	2,660	1610	4.3
Terrestrial	**15,323**	**804**	**12.3**
Forest	4,855	969	4.7
Tropical	1,900	2007	3.8
Temperate/Boreal	2,955	302	0.9
Grass/Rangelands	3,898	232	0.9
Wetlands	330	14785	4.9
Tidal Marsh/Mangroves	165	9990	1.6
Swamps/Floodplains	165	19580	3.2
Lakes/Rivers	200	8498	1.7
Desert	1,925		
Tundra	743		
Ice/Rock	1,640		
Cropland	1,400	92	0.1
Urban	332		
Total	51,625		**33.3**

Problems with the *Nature* paper
(as listed in the paper itself)

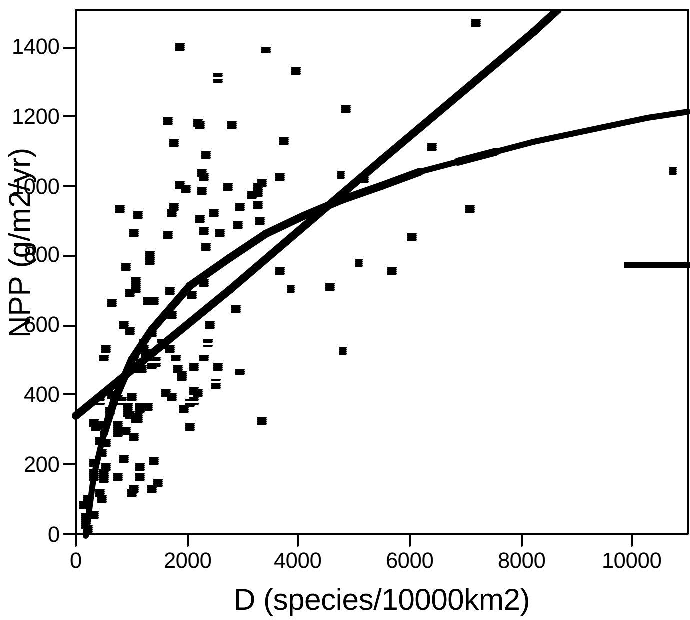
1. Incomplete (not all biomes studied well - some not at all)
2. Distortions in current prices are carried through the analysis
3. Most estimates based on current willingness-to-pay or proxies
4. Probably underestimates changes in supply and demand curves as ecoservices become more limiting
5. Assumes smooth responses (no thresholds or discontinuties)
6. Assumes spatial homogeneity of services within biomes
7. Partial equilibrium framework
8. Not necessarily based on sustainable use levels
9. Does not fully include “infrastructure” value of ecosystems
10. Difficulties and imprecision of making inter-country comparisons
11. Discounting (for the few cases where we needed to convert from stock to flow values)
12. Static snapshot; no dynamic interactions

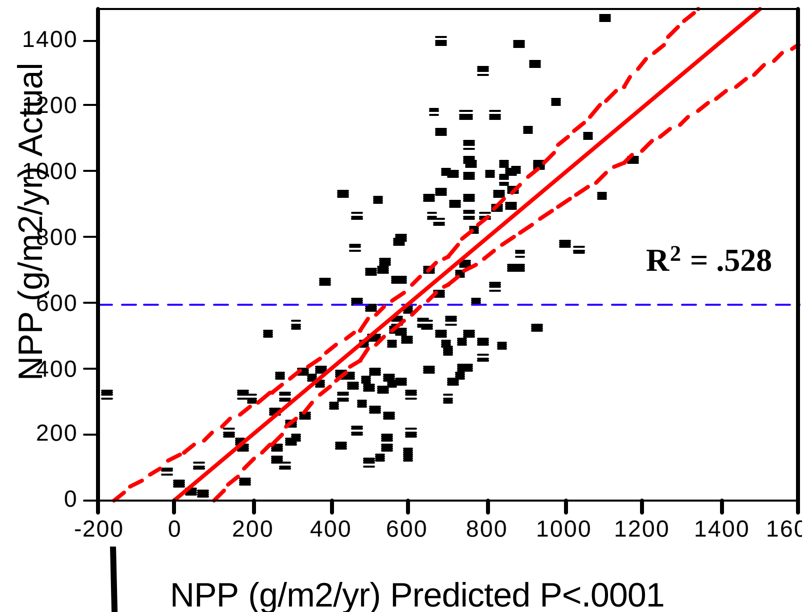
Solving any of these problems (except perhaps 6 which could go either way) will lead to larger values

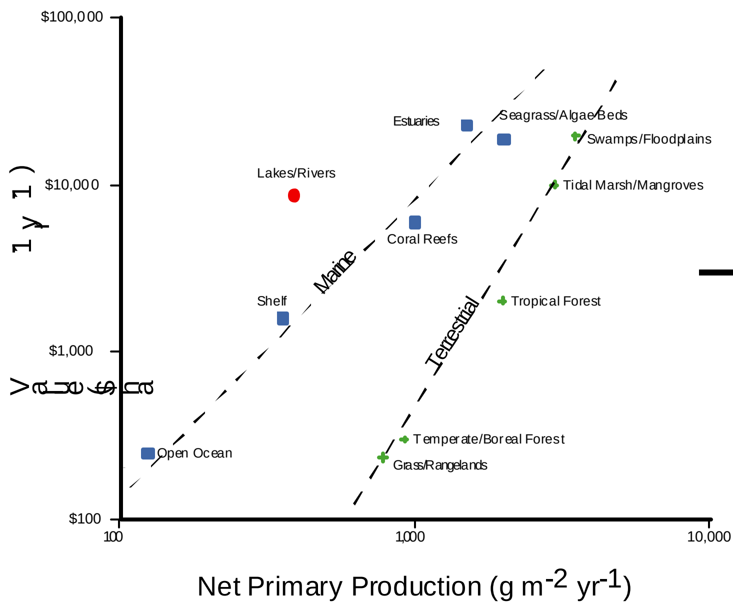


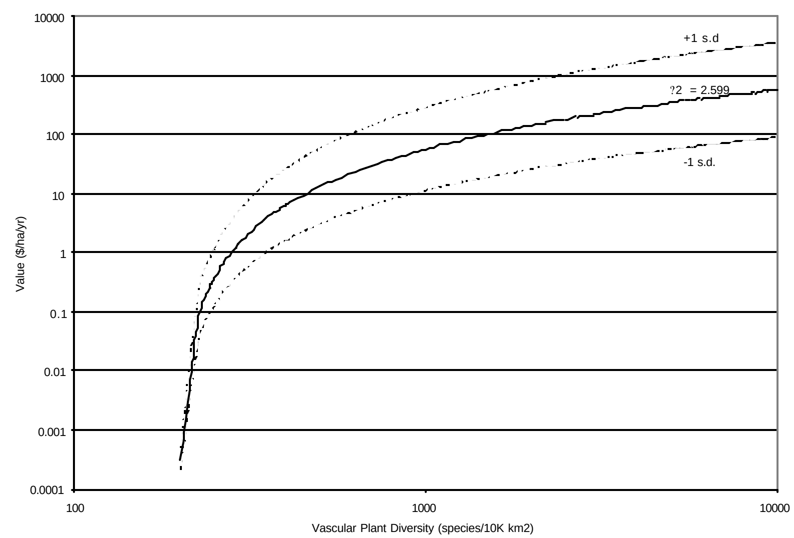
Linkages Between Biodiversity and the Value of Ecosystem Services

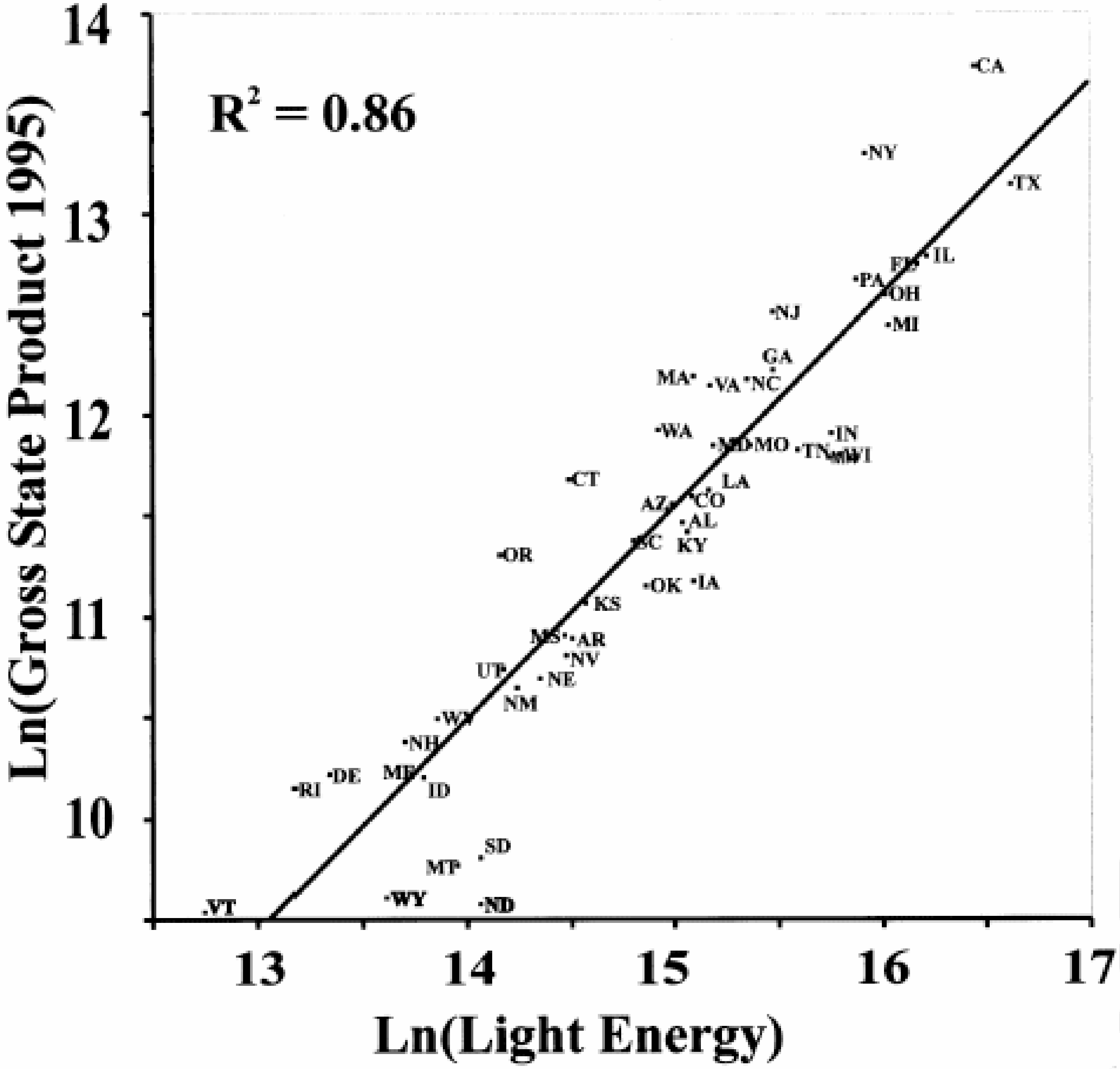
Global (by country) analysis of the relationship between plant species richness, NPP, and the value of ecosystem services











$R^2 = 0.86$
Ln(Gross State Product 1995)
Ln(Light Energy)
14
13
12
11
10
13
14
15
16
17
CA
NY
TX
IL
FL
PA
OH
NJ
MI
GA
MA
VA
NC
WA
IN
MD
MO
TN
WI
CT
LA
AZ
CO
AL
SC
KY
OR
OK
IA
KS
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AR
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UT
NE
NM
WV
NH
DE
RI
ME
ID
SD
MT
WY
ND
VT

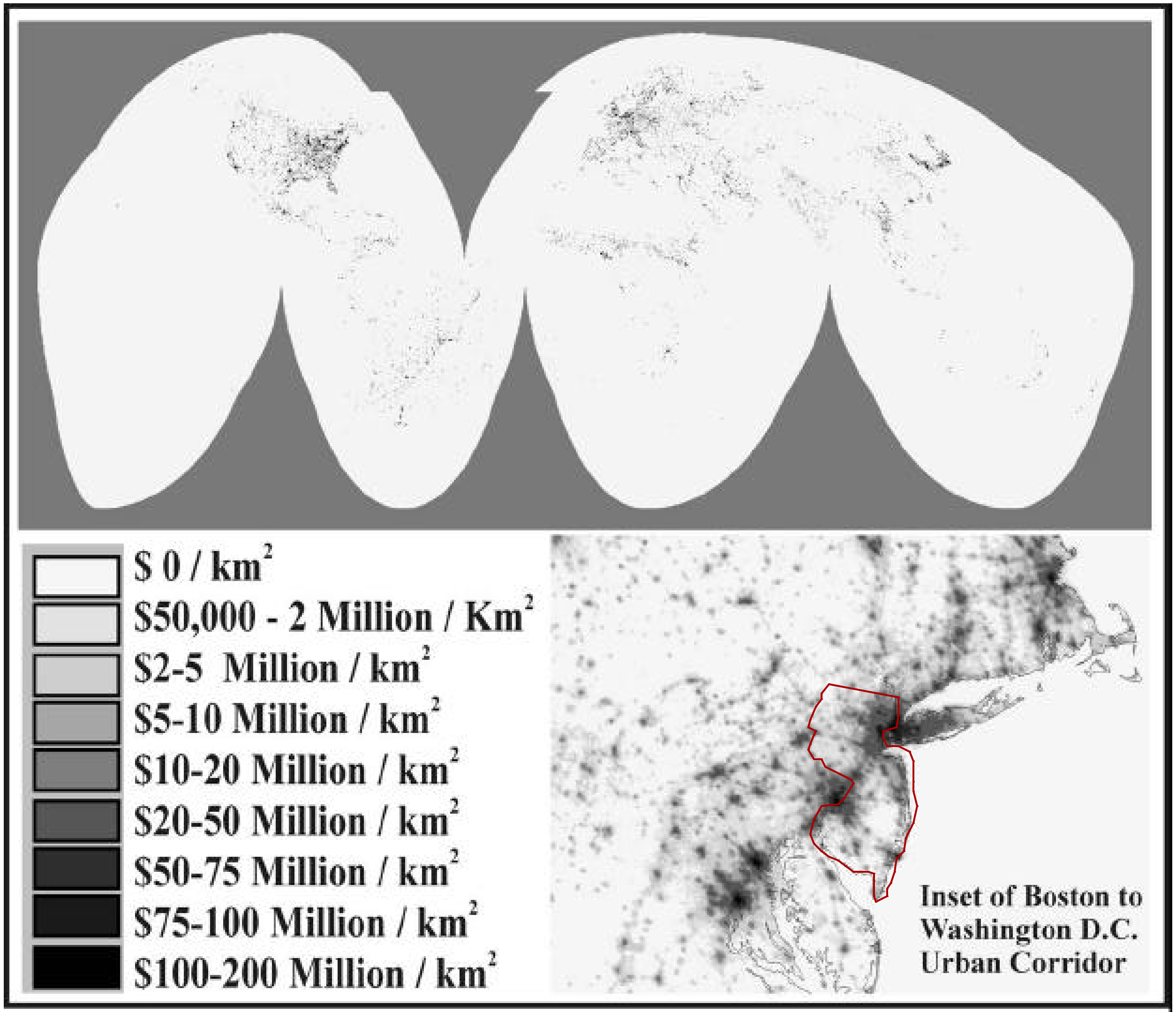


Figure 2: Global Map of Marketed Economic Activity as measured by Nighttime Satellite Image proxy

From: Sutton, P. C. and R. Costanza. 2002. Global estimates of market and non-market values derived from nighttime satellite imagery, land use, and ecosystem service valuation. *Ecological Economics* 41: 509-527

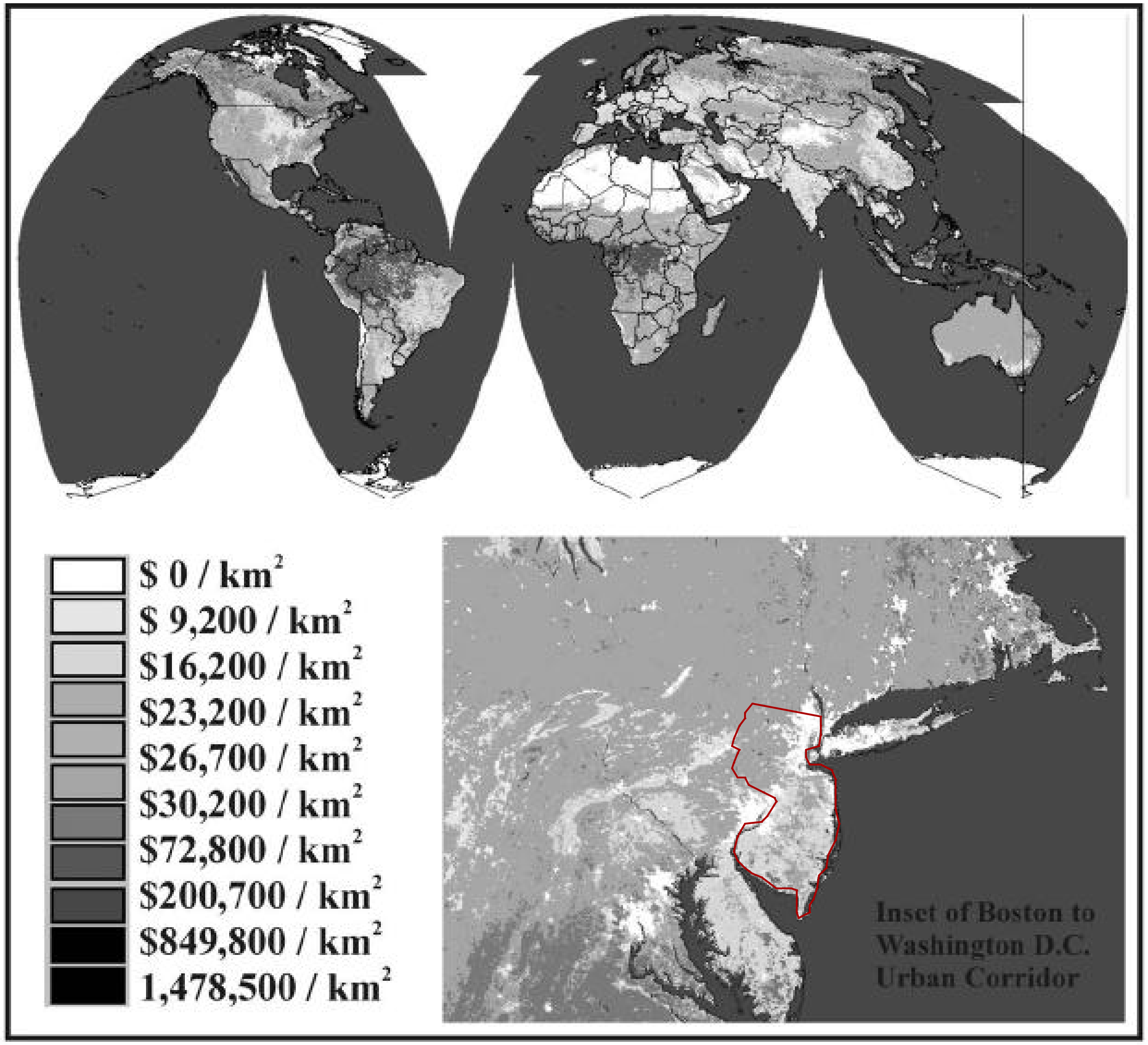
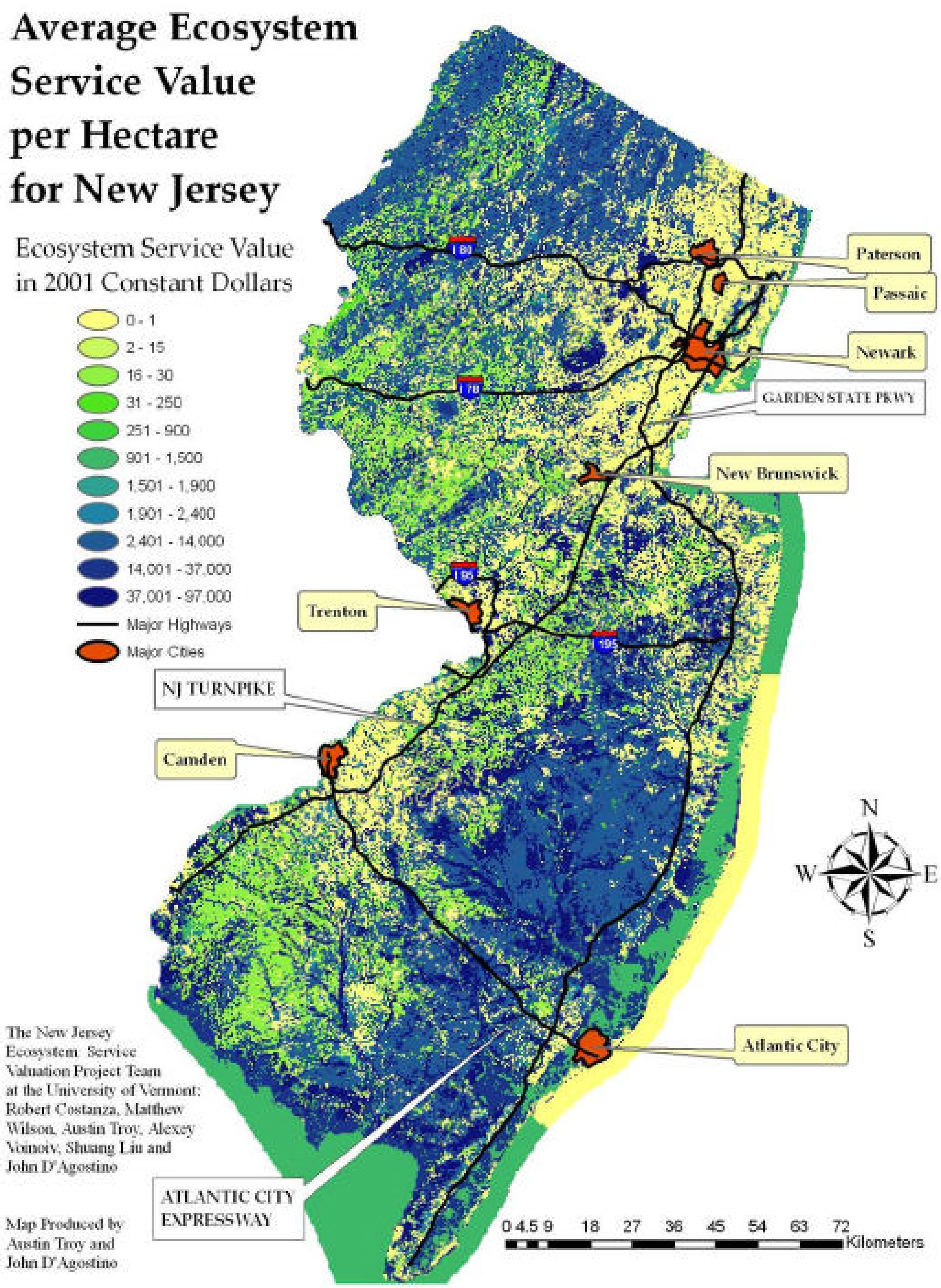


Figure 3: Global Map of Non-Marketed Economic Activity (ESP) arising from Ecosystem Services and derived from Land Cover at 1 km^2 (For National Totals See Table 1)

Valuation of New Jersey's Natural Capital and Ecosystem Services

Contract # SR04-075

New Jersey Department of Environmental Protection



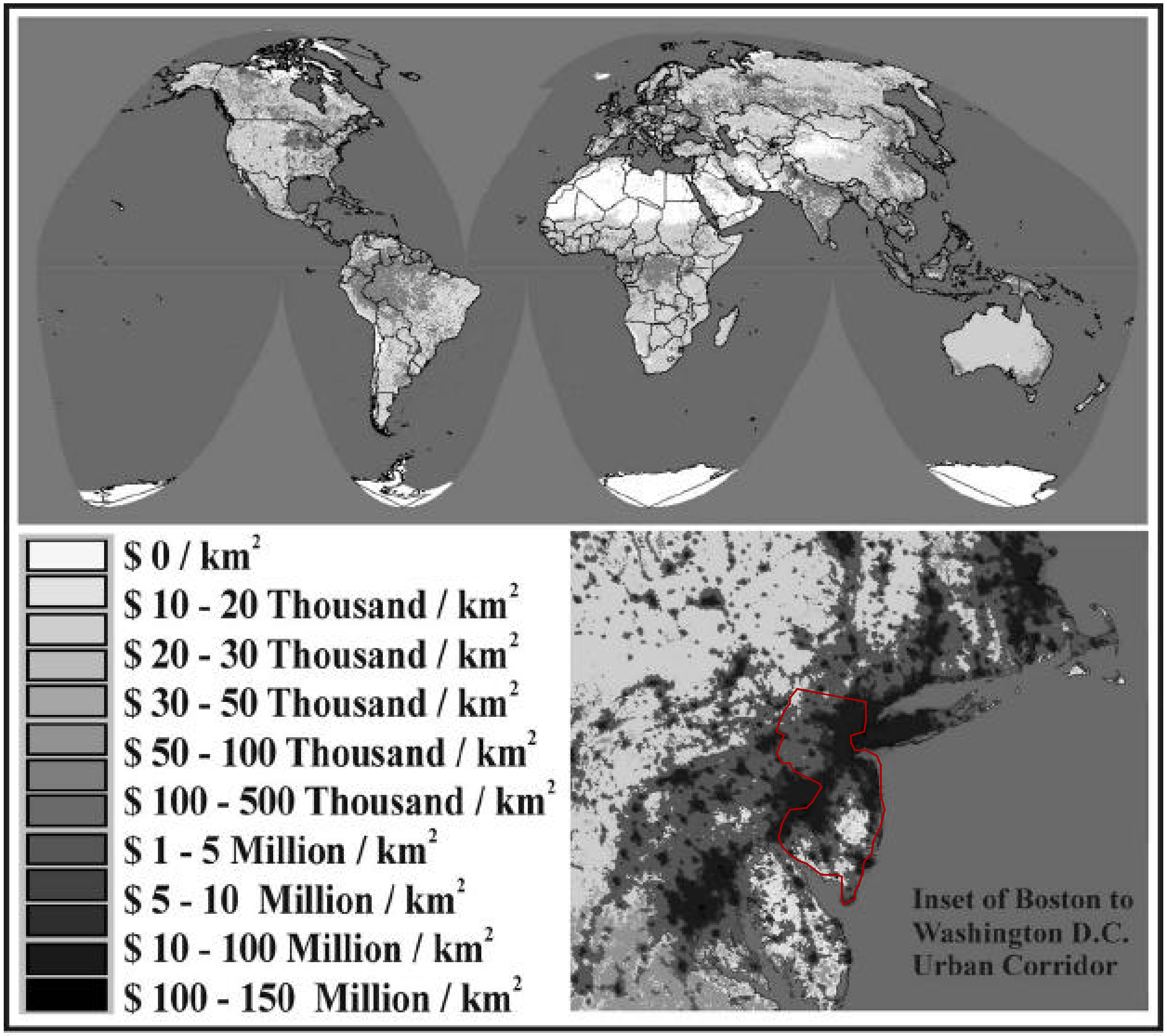


Figure 4: Subtotal Ecological-Economic Product (SEP = GDP + ESP) at 1 km2 resolution (w/ inset Boston -DC)

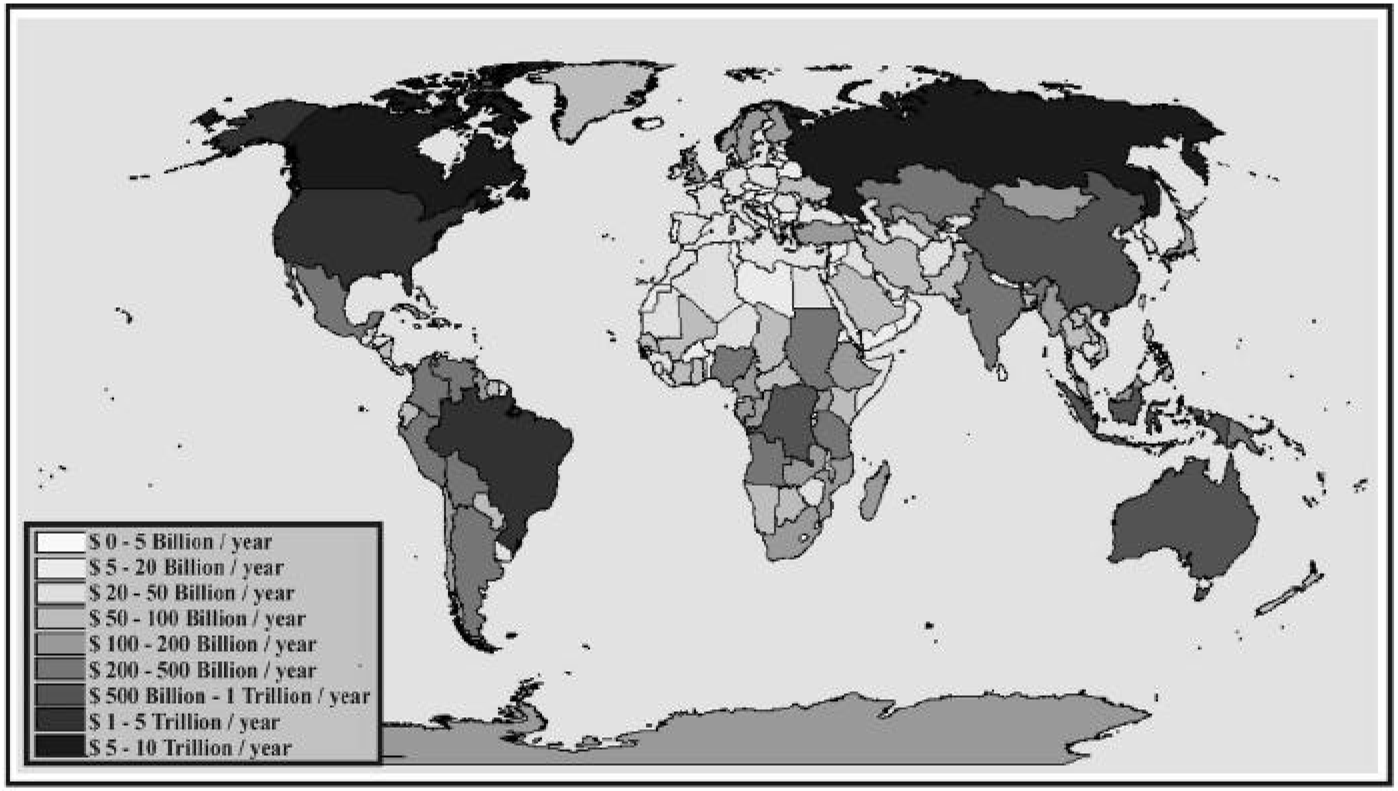


Figure 5: Aggregated National Map (choropleth) of ESP (Ecosystem Service Product)

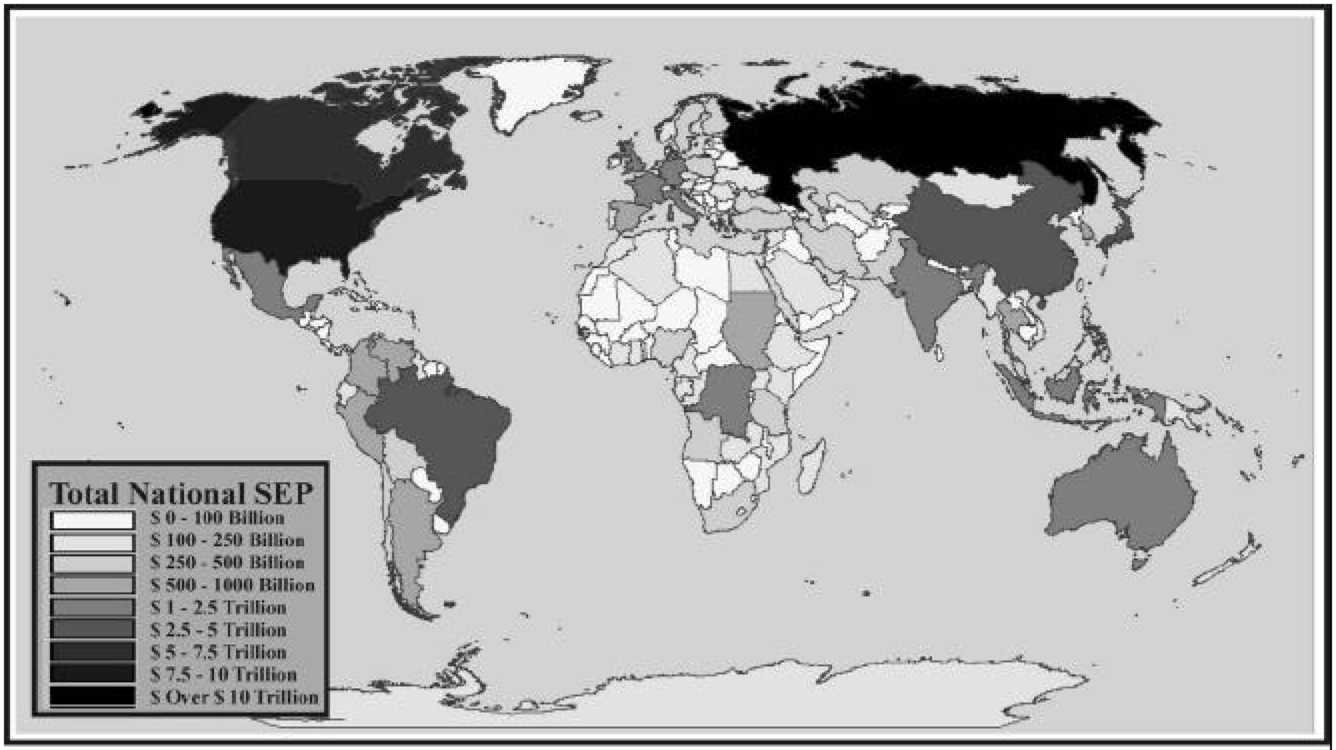


Figure 6: Aggregated National Map (choropleth) of SEP (Subtotal Ecological-Economic Product)

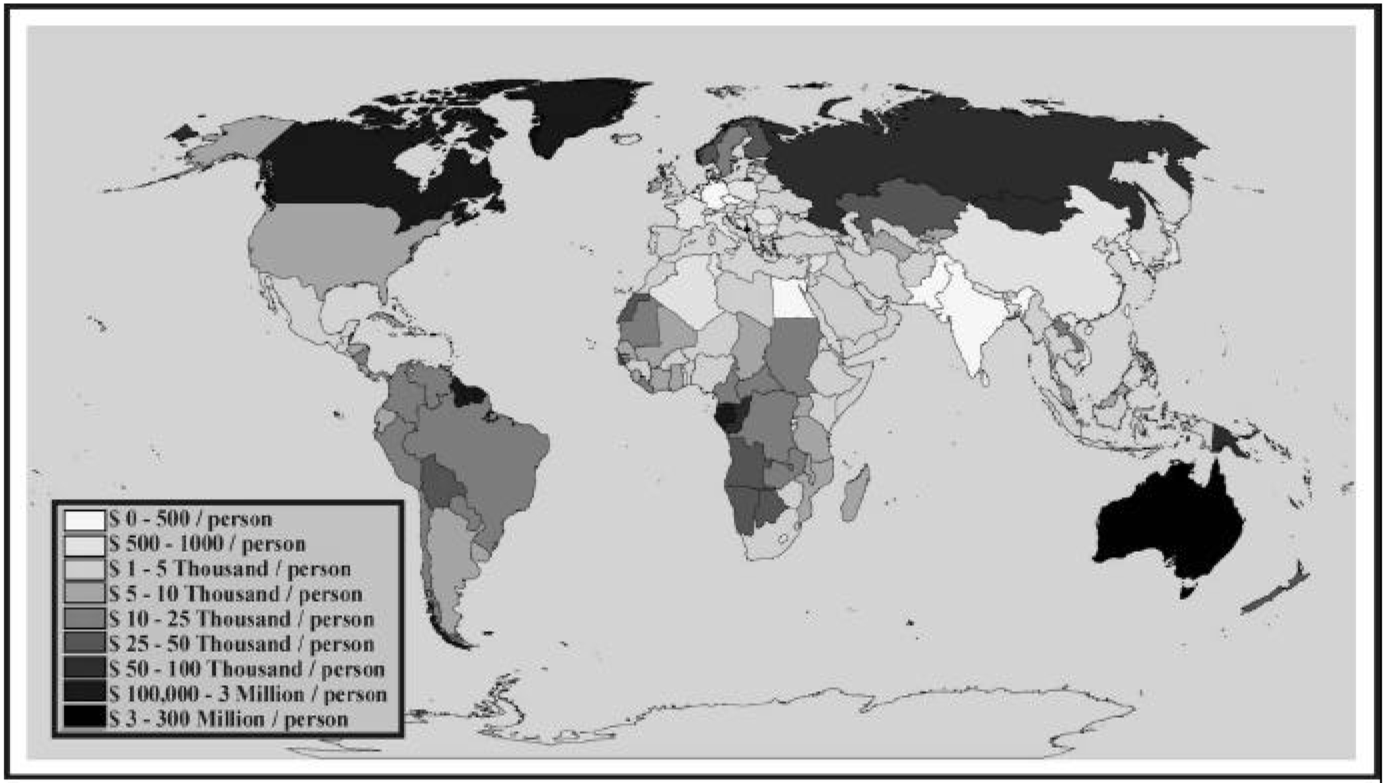
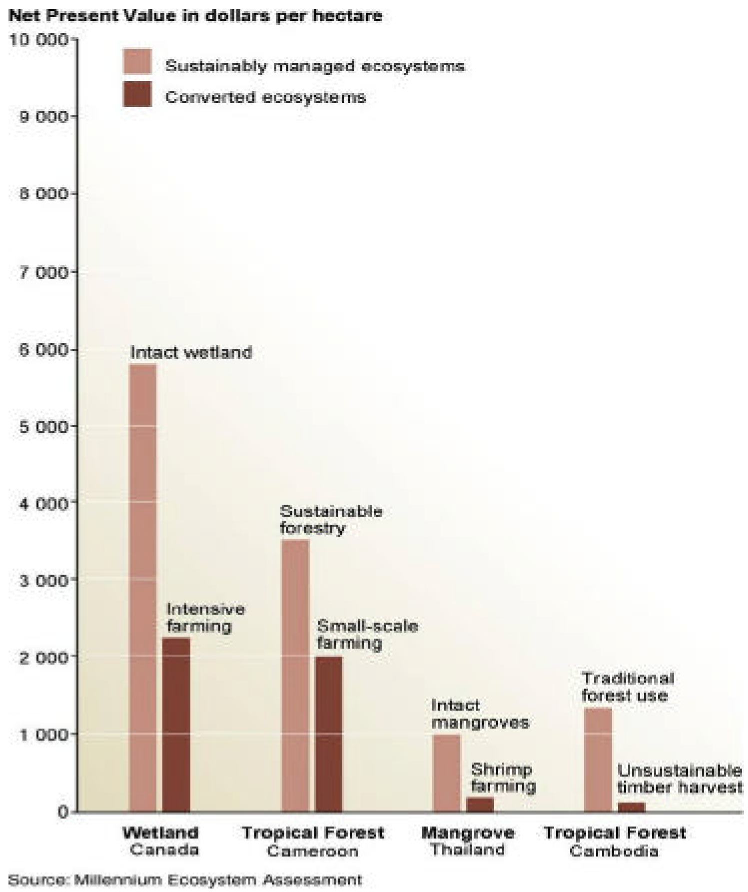


Figure 7: Agrregated National Map (choropleth) of SEP/ Capita

Degradation of ecosystem services often causes significant harm to human well-being

- The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion
- Conversion may still occur because private economic benefits are often greater for the converted system



Economic Reasons for Conserving Wild Nature

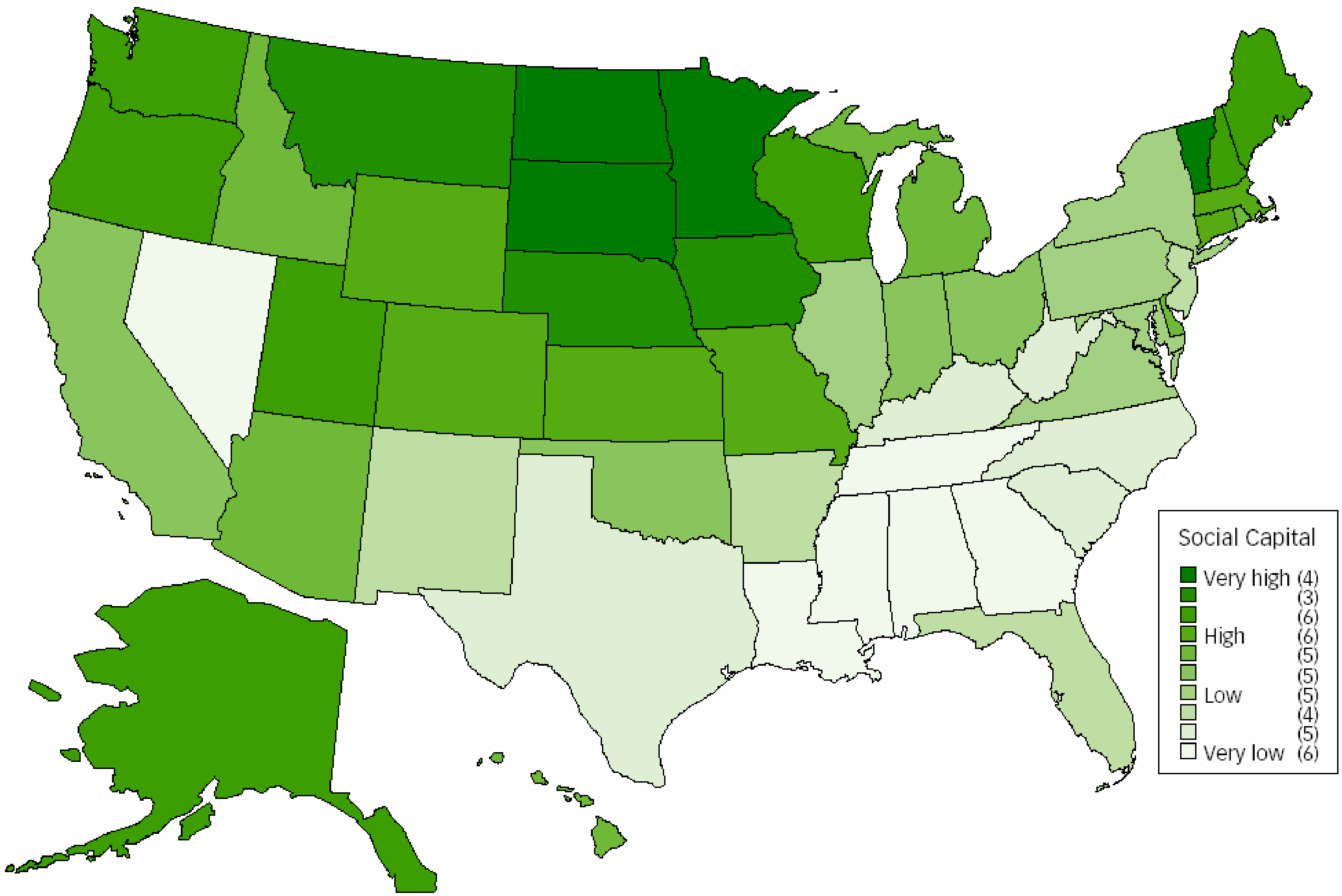
Costs of expanding and maintaining the current global reserve network to one covering 15% of the terrestrial biosphere and 30% of the marine biosphere **= $US 45 Billion/yr**

Benefits (Net value* of ecosystem services from the global reserve network) **= $US 4,400-5,200 Billion/yr**

***Net value is the difference between the value of services in a "wild" state and the value in the most likely human-dominated alternative**

Benefit/Cost Ratio = 100:1

(From: Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner 2002. Economic reasons for conserving wild nature. *Science* 297: 950-953)



From: R. Putnam, *Bowling Alone: The Collapse and Revival of American Community* NewYork: Simon and Schuster, 2000).

FIGURE 7.4

Violent crime is rarer in high social capital states

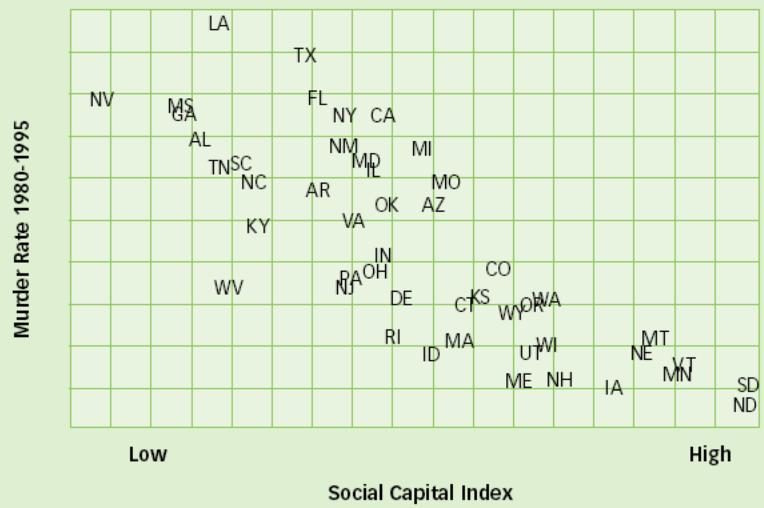


FIGURE 7.3

Kids watch less TV in high social capital states

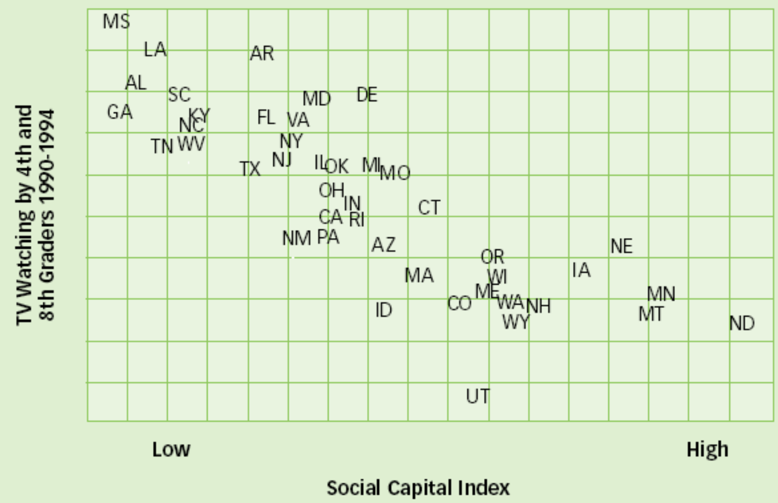


FIGURE 7.1

Schools work better in high social capital states

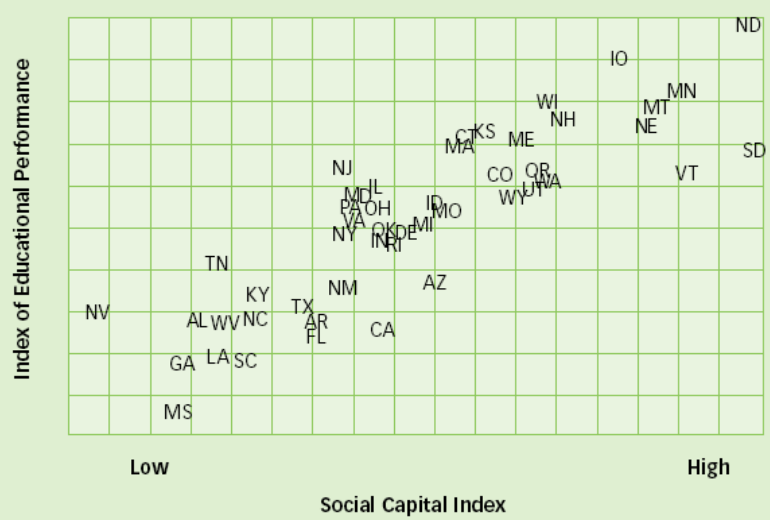
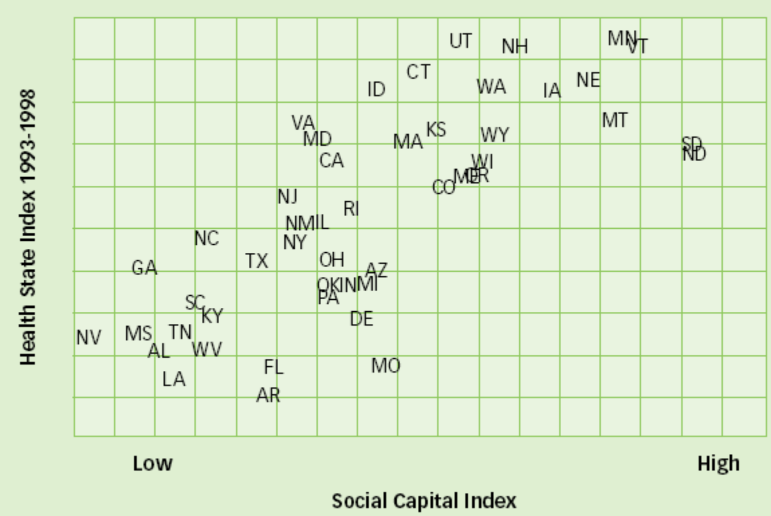


FIGURE 7.6

Health is better in high social capital states



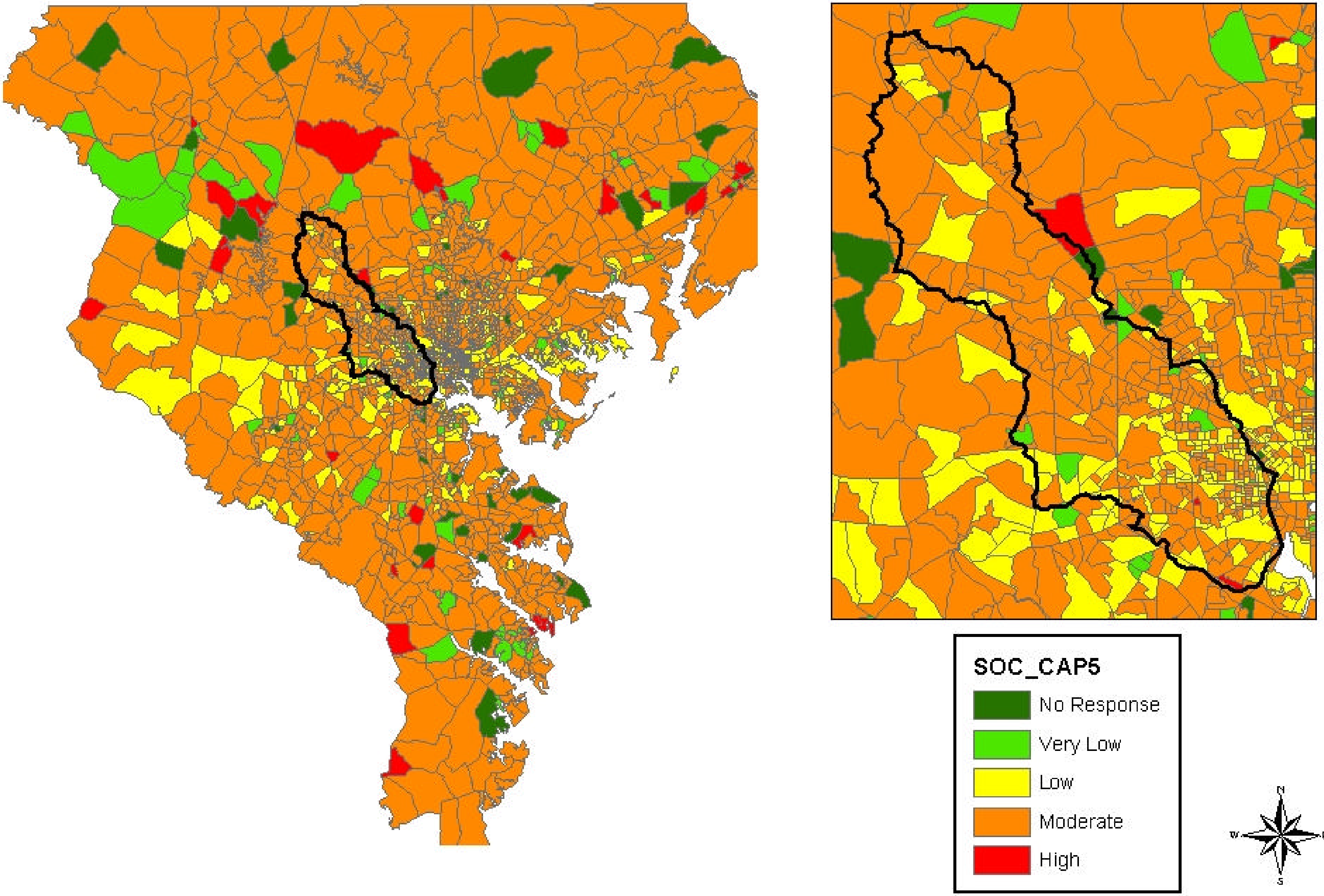
Social Capital Survey Questions

work by: Morgan Grove, Bill Burch, Matt Wilson, and Amanda Vermuri
as part of the Baltimore Ecosystem Study: http://www.ecostudies.org/bes/

- People in the neighborhood are willing to help one another*
- This is a close knit neighborhood*
- People in this neighborhood can be trusted*
- There are many opportunities to meet neighbors and work on solving community problems*
- Churches or temples and other volunteer groups are actively supportive of the neighborhood*
- There is an active neighborhood association
- Municipal (local) government services (such as sanitation, police, fire, health & housing dept) are adequately provided and support the neighborhood's quality

* Included in Social Capital Index; Cronbachs alpha = .7758

Social Capital Index by Census Block Group



Integrated Ecological Economic Modeling

- **Used as a Consensus Building Tool in an Open, Participatory Process**
- **Multi-scale, Landscape Scale and Larger**
- **Acknowledges Uncertainty and Limited Predictability**
- **Acknowledges Values of Stakeholders**
- **Simplifies by Maintaining Linkages and and Synthesizing**
- **Evolutionary Approach Acknowledges History, Limited Optimization, and the Co-Evolution of Humans and the Rest of Nature**

Three Step Modeling Process*

1. Scoping Models

high generality, low resolution models produced with broad participation by all the stakeholder groups affected by the problem.

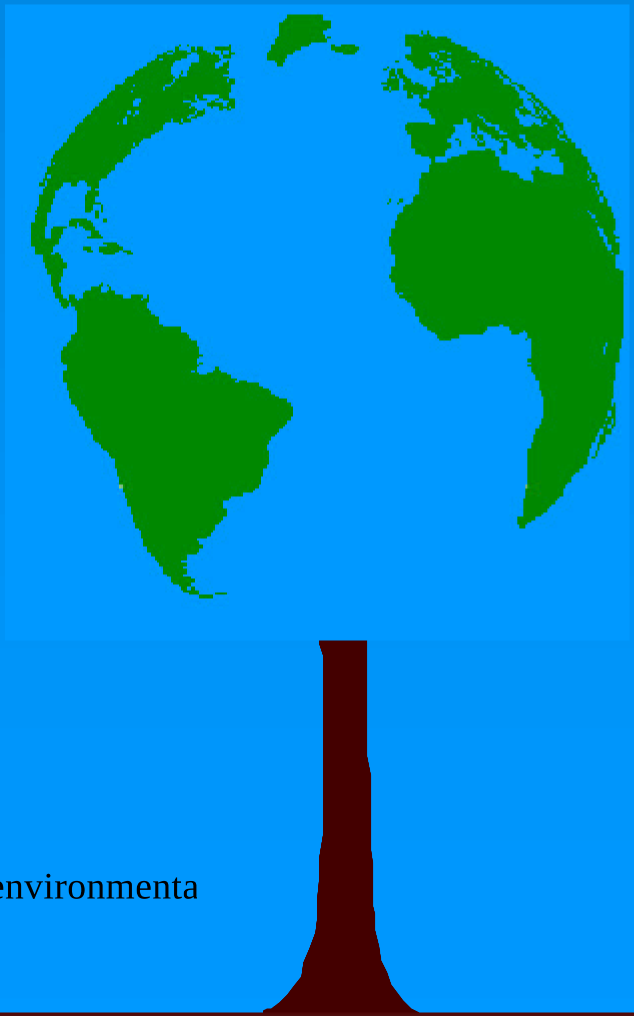
2. Research Models

more detailed and realistic attempts to replicate the dynamics of the particular system of interest with the emphasis on calibration and testing.

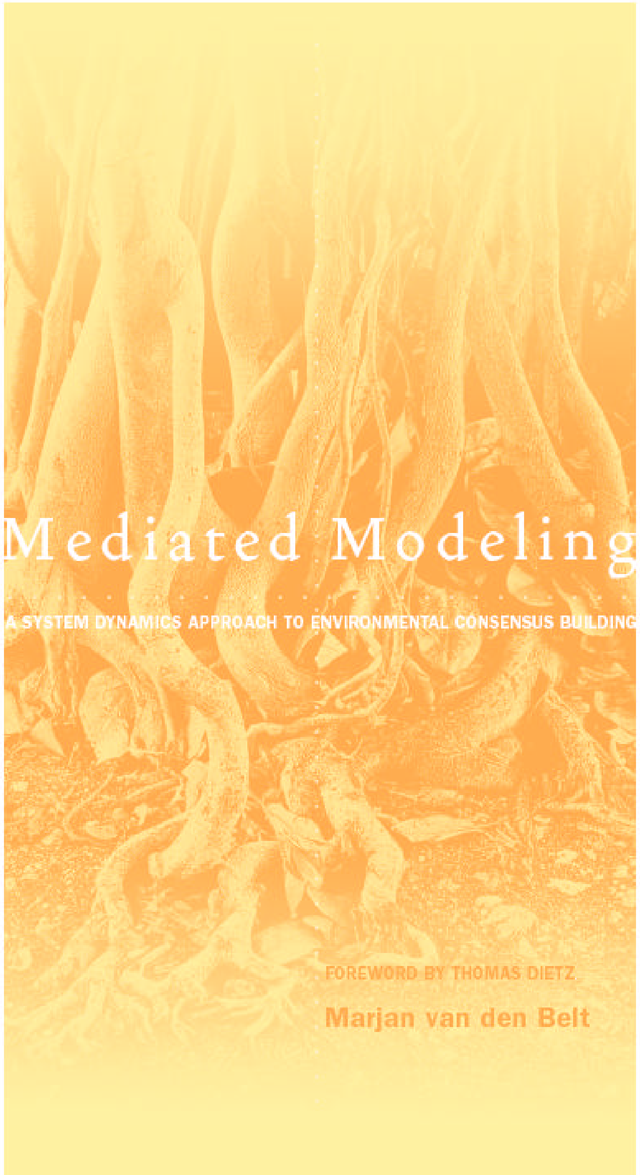
3. Management Models

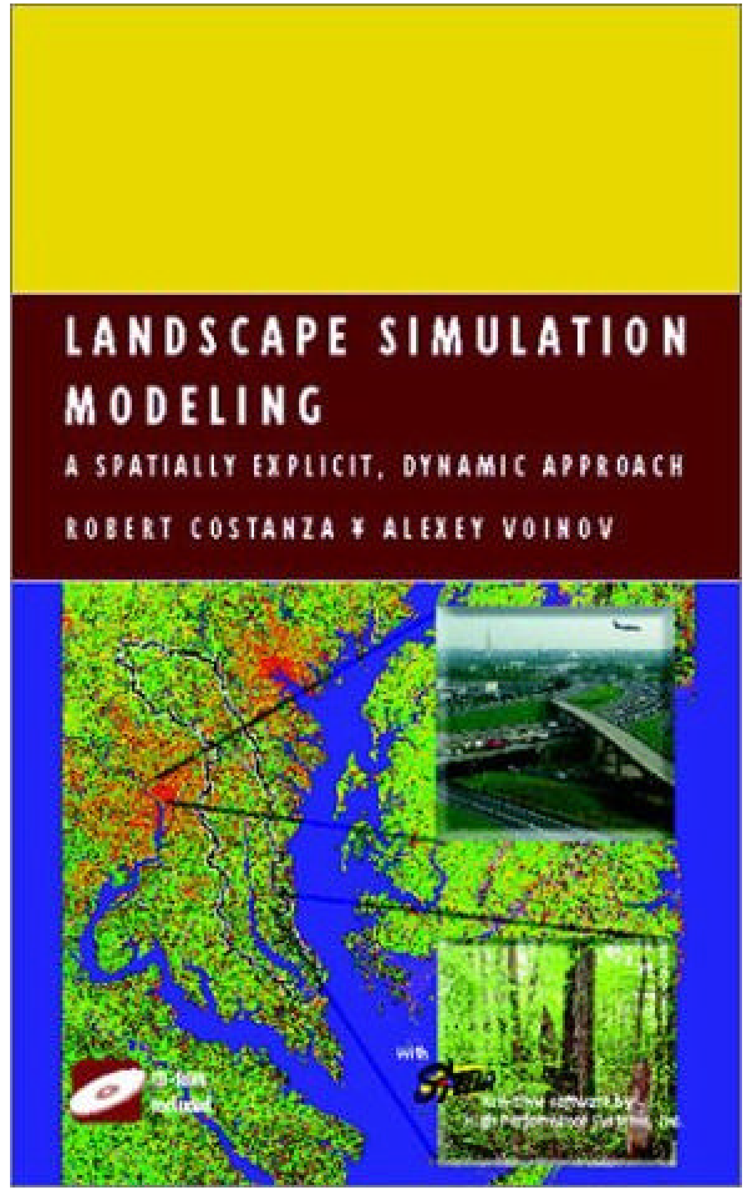
medium to high resolution models based on the previous two stages with the emphasis on producing future management scenarios - can be simply exercising the scoping or research models or may require further elaboration to allow application to management questions

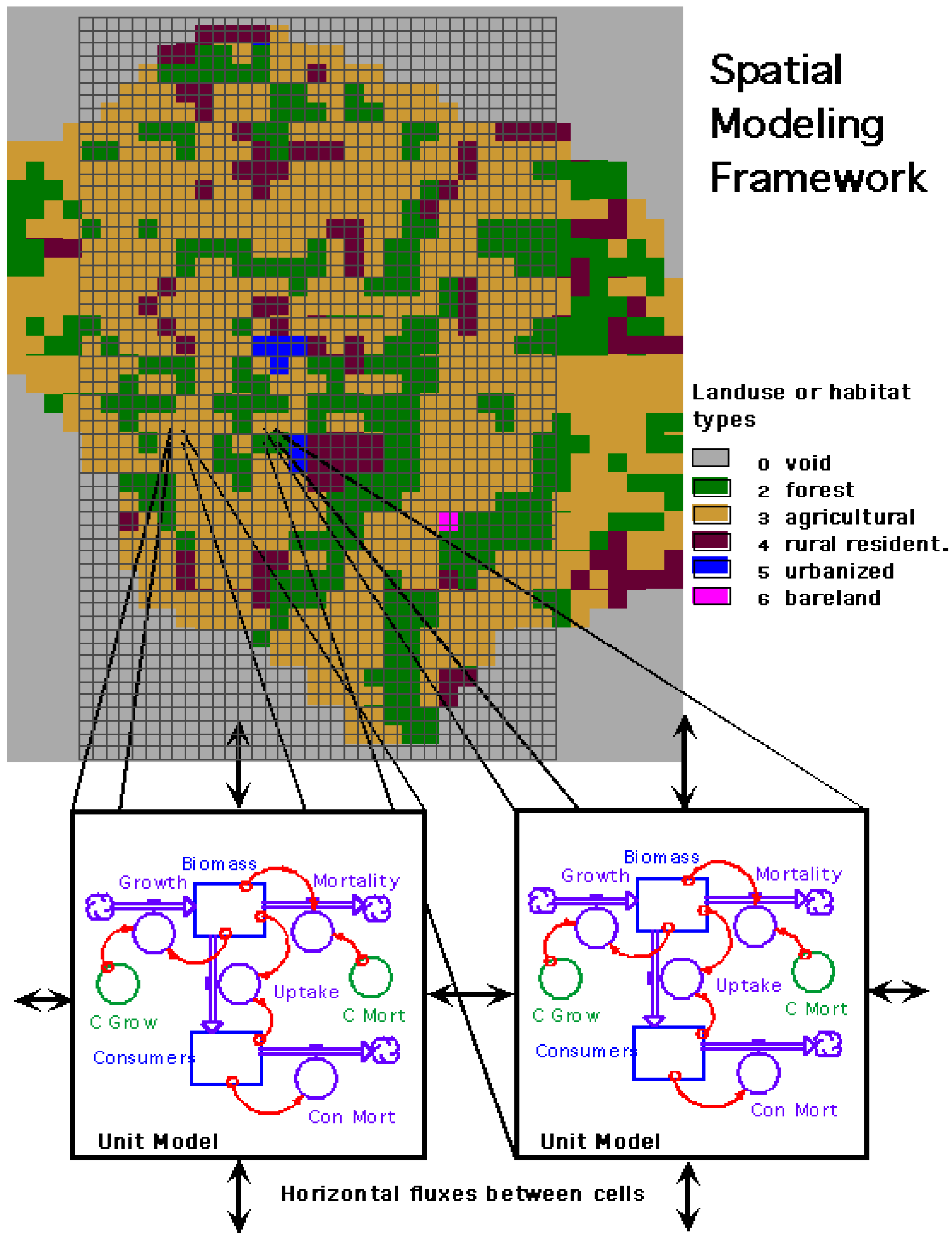
Increasing Complexity, Cost, Realism, and Precision

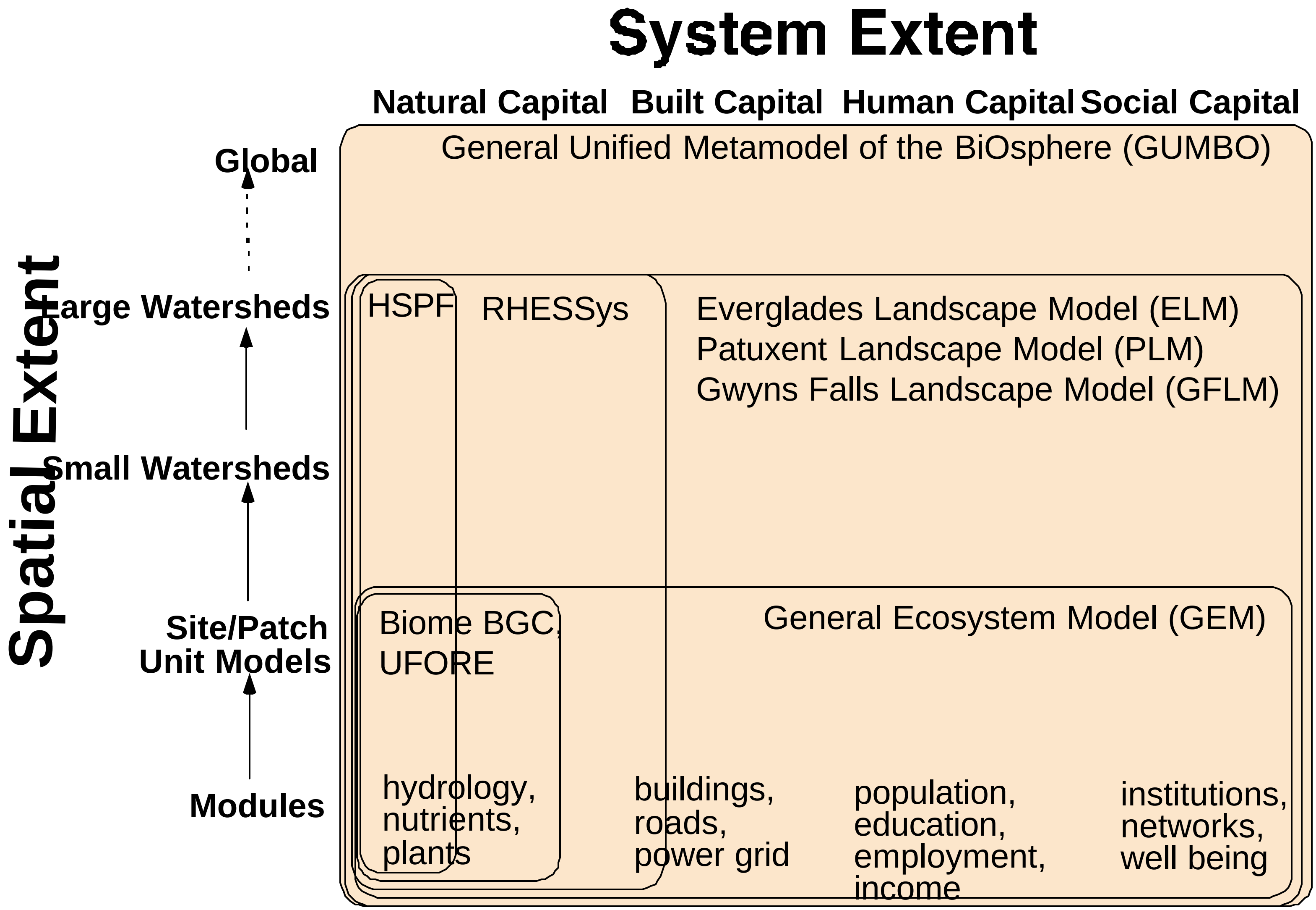


*from: Costanza, R. and M. Ruth. 1998. Using dynamic modeling to scope environmenta
and build consensus. *Environmental Management* 22:183-195.

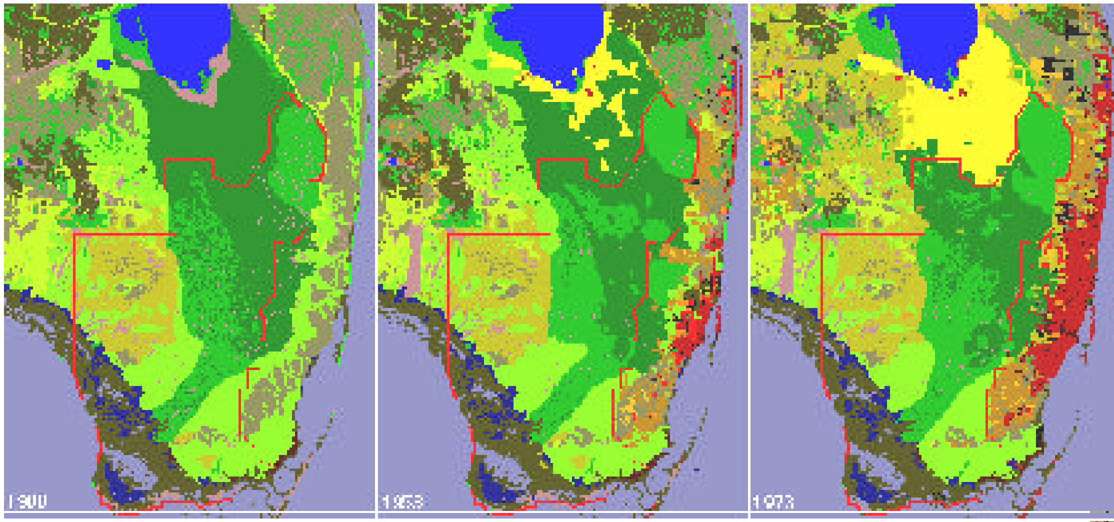

Mediated Modeling
A SYSTEM DYNAMICS APPROACH TO ENVIRONMENTAL CONSENSUS BUILDING
FOREWORD BY THOMAS DIETZ
Marjan van den Belt

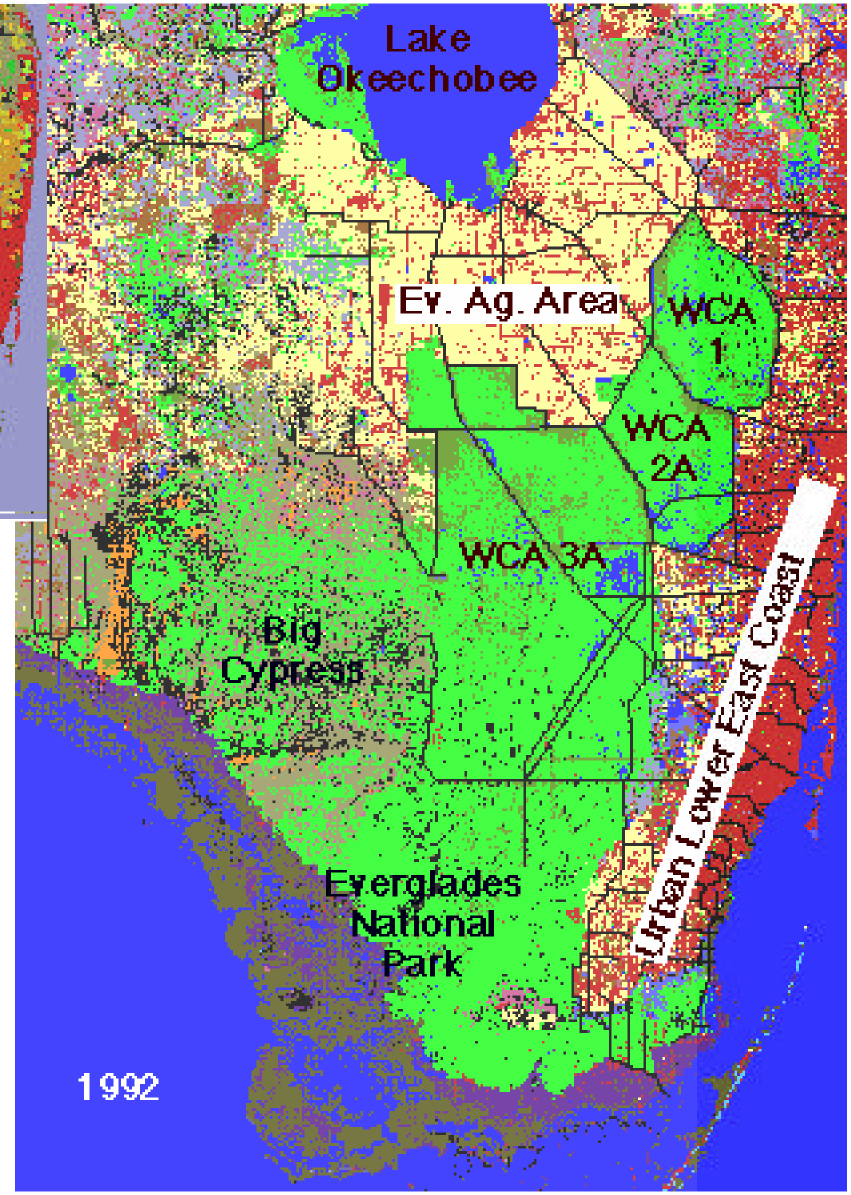

LANDSCAPE SIMULATION MODELING
A SPATIALLY EXPLICIT, DYNAMIC APPROACH
ROBERT COSTANZA ¥ ALEXEY VOINOV
with


Spatial Modeling Framework
Landuse or habitat types
0 void
2 forest
3 agricultural
4 rural resident.
5 urbanized
6 bareland
Biomass
Growth
Mortality
Uptake
C Grow
C Mort
Consumers
Con Mort
Unit Model
Biomass
Growth
Mortality
Uptake
C Grow
C Mort
Consumers
Con Mort
Unit Model
Horizontal fluxes between cells



Suite of interactive and intercalibrated models over a range of spatial, temporal and system scales (extents and resolutions)





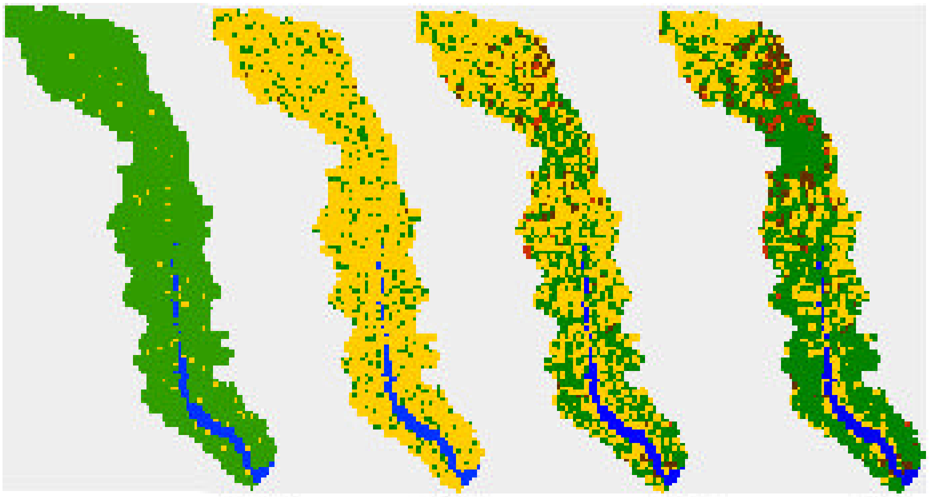
The Everglades Landscape Model (ELM v2.1)

http://www.sfwmd.gov/org/erd/esr/ELM.html

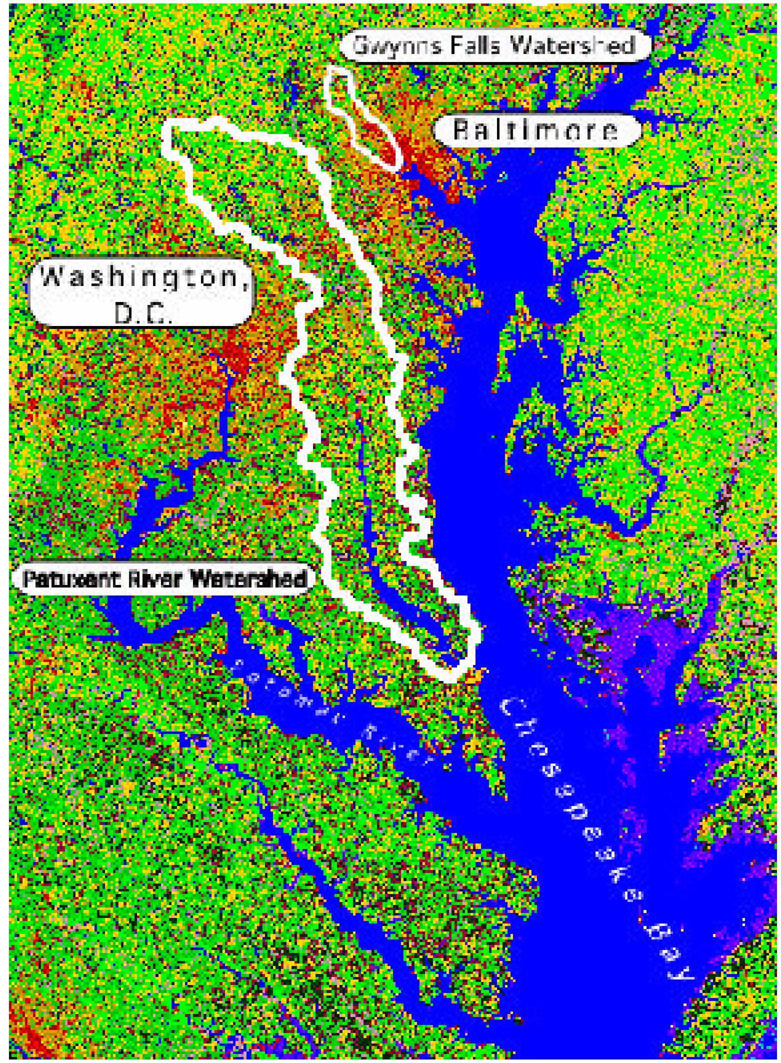
The ELM is a regional scale ecological model designed to predict the landscape response to different water management scenarios in south Florida, USA. The ELM simulates changes to the hydrology, soil & water nutrients, periphyton biomass & community type, and vegetation biomass & community type in the Everglades region.

Current Developers
South Florida Water Management District
H. Carl Fitz
Fred H. Sklar
Yegang Wu
Charles Cornwell
Tim Waring

Recent Collaborators
University of Maryland, Institute for Ecological Economics
Alexey A. Voinov
Robert Costanza
Tom Maxwell
Florida Atlantic University
Matthew Evett



	1700	1850	1953	1972
Forest	2386	348	911	1391
Residential	0	7	111	195
Urban	0	0	28	56
Agro	56	2087	1391	800



The Patuxent and Gwynns Falls Watershed Model s (PLM and GFLM)

http://www.uvm.edu/giee/PLM

This project is aimed at developing integrated knowledge and new tools to enhance predictive understanding of watershed ecosystems (including processes and mechanisms that govern the interconnect - ed dynamics of water, nutrients, toxins, and biotic components) and their linkage to human factors affecting water and watersheds. The goal is effective management at the watershed scale.

Participants Include:

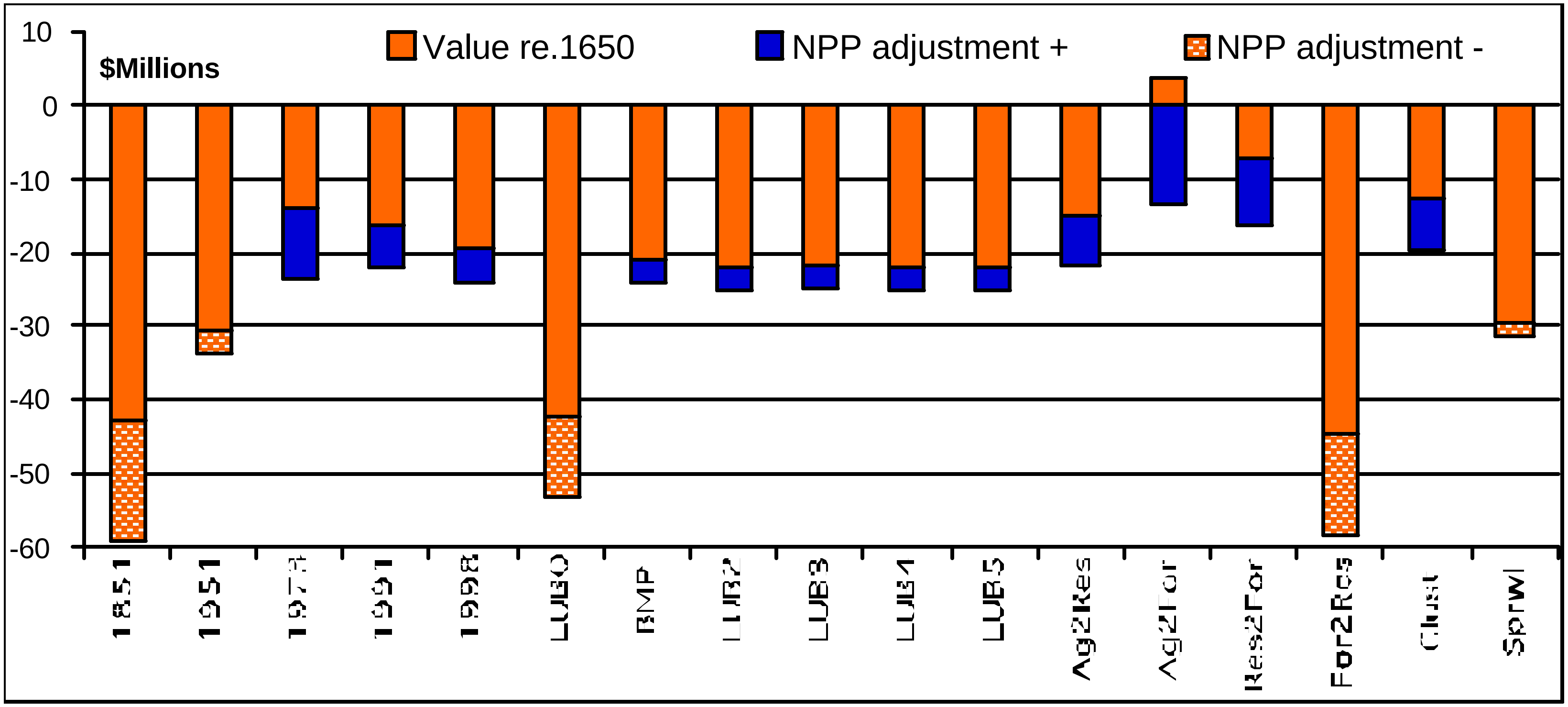
Robert Costanza
Roelof Boumans
Walter Boynton
Thomas Maxwell
Steve Seagle
Ferdinando Villa
Alexey Voinov
Helena Voinov
Lisa Wainger

Patuxent Watershed Scenarios*

		Land Use				Nitrogen Loading				Nitrogen to Estuary			Hydrology		N in GW	NPP
		Forest	Resid	Urban	Agro	Atmos	Fertil	Decomp	Septic	N aver.	N max	N min	Wmax	Wmin	N gw c.	NPP
	Scenario	number of cells				kg/ha/year				mg/l			m/year		mg/l	kg/m2/y
1	1650	2386	0	0	56	3.00	0.00	162.00	0.00	3.14	11.97	0.05	101.059	34.557	0.023	2.185
2	1850	348	7	0	2087	5.00	106.00	63.00	0.00	7.17	46.61	0.22	147.979	22.227	0.25	0.333
3	1950	911	111	28	1391	96.00	110.00	99.00	7.00	11.79	42.34	0.70	128.076	18.976	0.284	1.119
4	1972	1252	223	83	884	86.00	145.00	119.00	7.00	13.68	60.63	0.76	126.974	19.947	0.281	1.72
5	1990	1315	311	92	724	86.00	101.00	113.00	13.00	10.18	40.42	1.09	138.486	18.473	0.265	1.654
6	1997	1195	460	115	672	91.00	94.00	105.00	18.00	11.09	55.73	0.34	147.909	18.312	0.289	1.569
7	BuildOut	312	729	216	1185	96.00	155.00	61.00	21.00	12.89	83.03	2.42	174.890	11.066	0.447	0.558
8	BMP	1195	460	115	672	80.00	41.00	103.00	18.00	5.68	16.41	0.06	148.154	16.736	0.23	1.523
9	LUB1	1129	575	134	604	86.00	73.00	98.00	8.00	8.05	39.71	0.11	150.524	17.623	0.266	1.494
10	LUB2	1147	538	134	623	86.00	76.00	100.00	11.00	7.89	29.95	0.07	148.353	16.575	0.269	1.512
11	LUB3	1129	577	134	602	86.00	73.00	99.00	24.00	7.89	29.73	0.10	148.479	16.750	0.289	1.5
12	LUB4	1133	564	135	610	86.00	74.00	100.00	12.00	8.05	29.83	0.07	148.444	16.633	0.271	1.501
13	agro2res	1195	1132	115	0	86.00	0.00	96.00	39.00	5.62	15.13	0.11	169.960	17.586	0.292	1.702
14	agro2frst	1867	460	115	0	86.00	0.00	134.00	18.00	4.89	12.32	0.06	138.622	21.590	0.142	2.258
15	res2frst	1655	0	115	672	86.00	82.00	130.00	7.00	7.58	23.50	0.10	120.771	20.276	0.18	1.95
16	frst2res	0	1655	115	672	86.00	82.00	36.00	54.00	9.27	39.40	1.89	183.565	9.586	0.497	0.437
17	cluster	1528	0	276	638	86.00	78.00	121.00	17.00	7.64	25.32	0.09	166.724	17.484	0.216	1.792
18	sprawl	1127	652	0	663	86.00	78.00	83.00	27.00	8.48	25.43	0.11	140.467	17.506	0.349	1.222

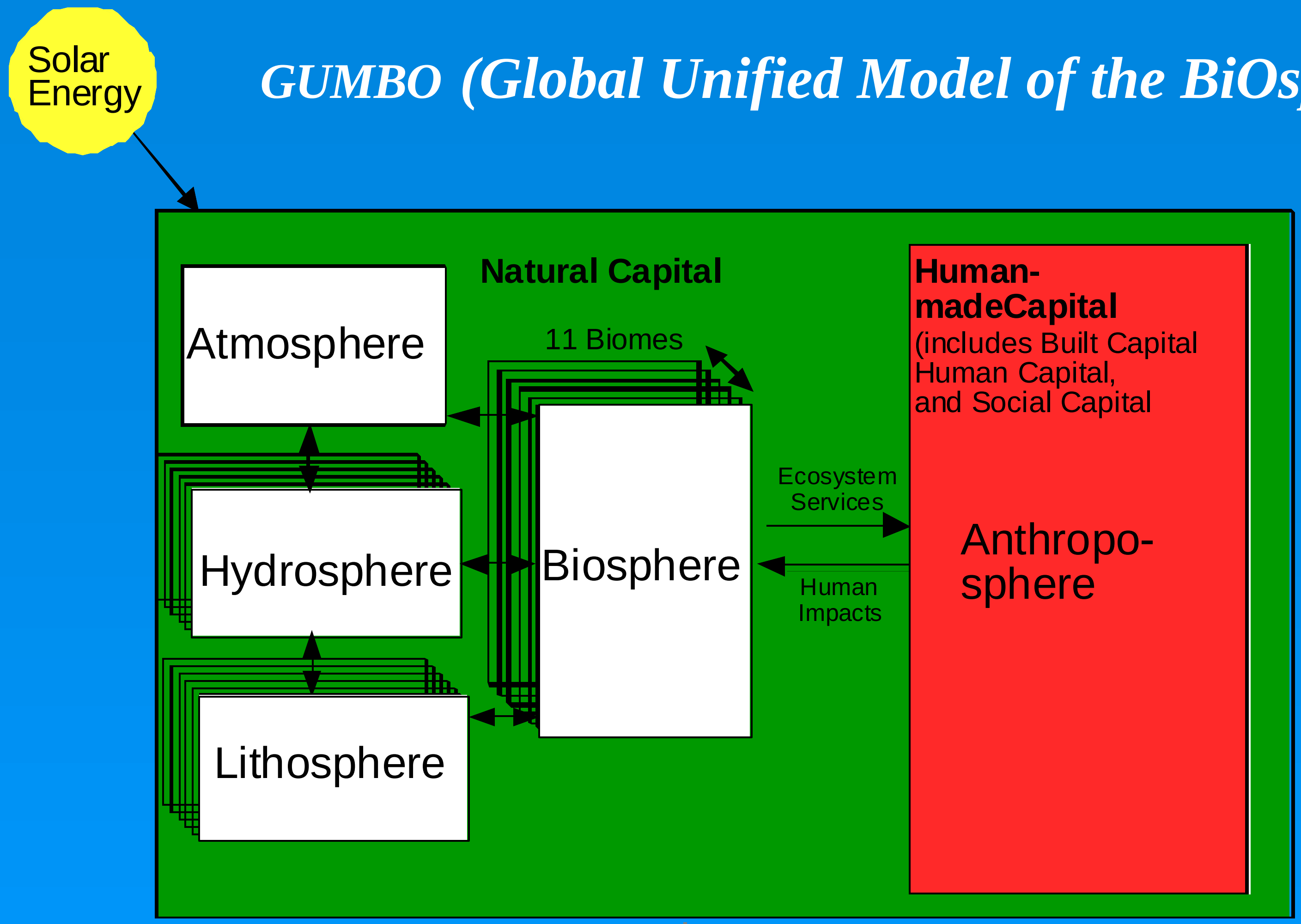
* From: Costanza, R., A. Voinov, R. Boumans, T. Maxwell, F. Villa, L. Wainger, and H. Voinov. 2002. Integrated ecological economic modeling of the Patuxent River watershed, Maryland. *Ecological Monographs* 72:203-231.

Results



- **Change in value of ecosystem services since 1650 calculated based on values estimated for different land use types (Costanza, et al., 1997). Further adjusted by NPP values calculated by the model. In some cases the NPP adjustment further decreased the ES value (-), in other cases it increased it (+).**

GUMBO (Global Unified Model of the BiOsphere)



From: Boumans, R., R. Costanza, J. Farley, M. A. Wilson, R. Portela, J. Rotmans, F. Villa, and M. Grasso. 2002. Modeling the Dynamics of the Integrated Earth System and the Value of Global Ecosystem Services Using the GUMBO Model. *Ecological Economics* 41: 529-560

See also: Portella, R. R. Boumans, and R. Costanza. Ecosystem services from Brazil's Amazon rainforest: Modeling their contribution to human's regional economy and welfare and the potential role of carbon mitigation projects on their continued provision.

Global Unified Metamodel of the BiOsphere (GUMBO)

- was developed to simulate the integrated earth system and assess the dynamics and values of ecosystem services.
- is a "metamodel" in that it represents a synthesis and a simplification of several existing dynamic global models in both the natural and social sciences at an intermediate level of complexity.
- the current version of the model contains 234 state variables, 930 variables total, and 1715 parameters.
- is the first global model to include the dynamic feedbacks among human technology, economic production and welfare, and ecosystem goods and services within the dynamic earth system.
- includes modules to simulate carbon, water, and nutrient fluxes through the *Atmosphere*, *Lithosphere*, *Hydrosphere*, and *Biosphere* of the global system. Social and economic dynamics are simulated within the *Anthroposphere*.
- links these five spheres across eleven biomes, which together encompass the entire surface of the planet.
- simulates the dynamics of eleven major ecosystem goods and services for each of the biomes

GUMBO Conclusions

- To our knowledge, no other global models have yet achieved the level of dynamic integration between the biophysical earth system and the human socioeconomic system incorporated in GUMBO. This is an important first step.
- Historical calibrations from 1900 to 2000 for 14 key variables for which quantitative time series data was available produced an average R^2 of .922.
- A range of future scenarios representing different assumptions about future technological change, investment strategies and other factors have been simulated
- Assessing global sustainability can only be done using a dynamic integrated model of the type we have created in GUMBO. But one is still left with decisions about *what* to sustain (i.e. GWP, welfare, welfare per capita, etc.) GUMBO allows these decisions to be made explicitly and in the context of the complex world system. It allows both desirable and sustainable futures to be examined.
- Ecosystem services are highly integrated into the model, both in terms of the biophysical functioning of the earth system and in the provision of human welfare. Both their physical and value dynamics are shown to be quite complex.
- The overall value of ecosystem services, in terms of their relative contribution to both the production and welfare functions, is shown to be significantly higher than GWP (4.5 times in this preliminary version of the model).
- “Technologically skeptical” investment policies are shown to have the best chance (given uncertainty about key parameters) of achieving high and sustainable welfare per capita. This means increased relative rates of investment in knowledge, social capital, and natural capital, and reduced relative rates of consumption and investment in built capital.

Lisbon Principles of Sustainable Governance:

1. Responsibility Principle

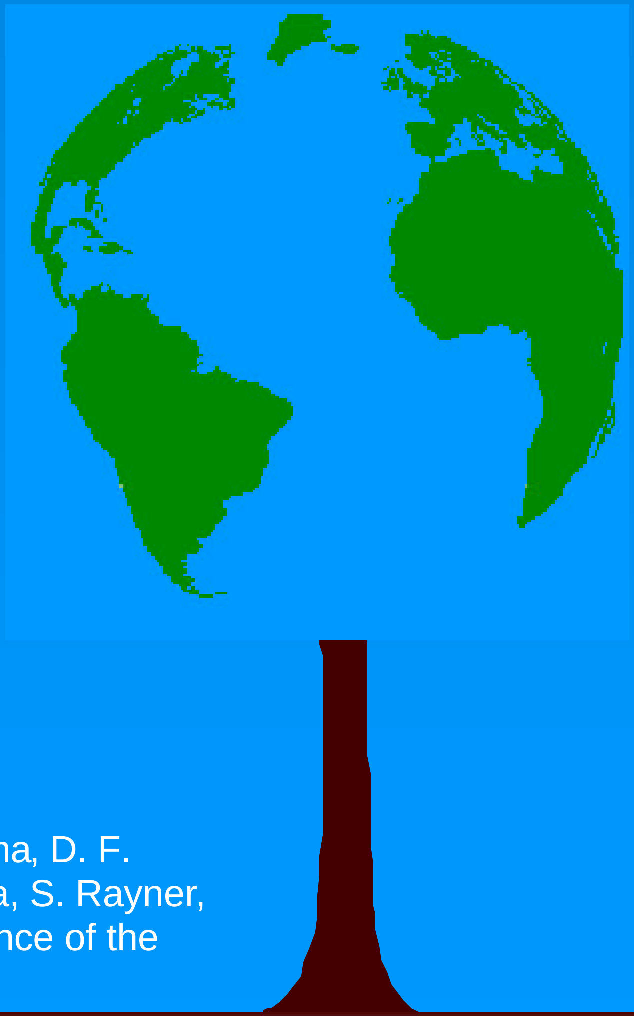
2. Scale-Matching Principle

3. Precautionary Principle

4. Adaptive Management Principle

5. Full Cost Allocation Principle

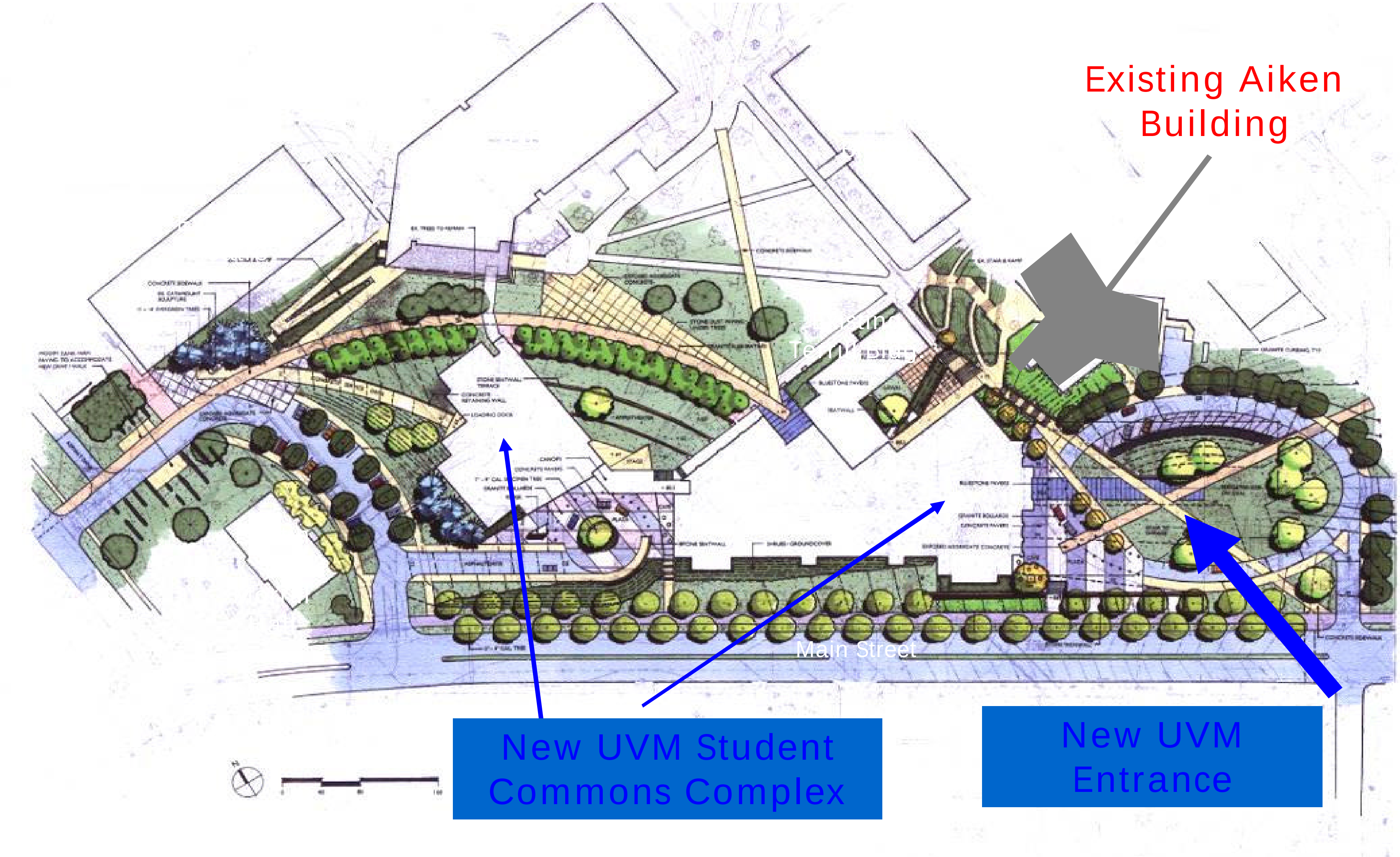
6. Participation Principle



From: Costanza, R. F. Andrade, P. Antunes, M. van den Belt, D. Boersma, D. F. Boesch, F. Catarino, S. Hanna, K. Limburg, B. Low, M. Molitor, G. Pereira, S. Rayner, R. Santos, J. Wilson, M. Young. 1998. Principles for sustainable governance of the oceans. *Science* 281:198-199.

http://www.global-community.biz/conference/

Building the Environmental University



Building the Environmental University

Blurring the Boundaries by

Integrating:

- **Across Teaching, Research, and Service**
- **Across Disciplines**
- **Across Academic Units**
- **Across Faculty, Students, and Stakeholders**
- **Across Theory and Application**
- **Across Science and Society**

Creating A New Model for Higher Education

Using Problem-Based (Atelier) courses

Aiken Design Competition

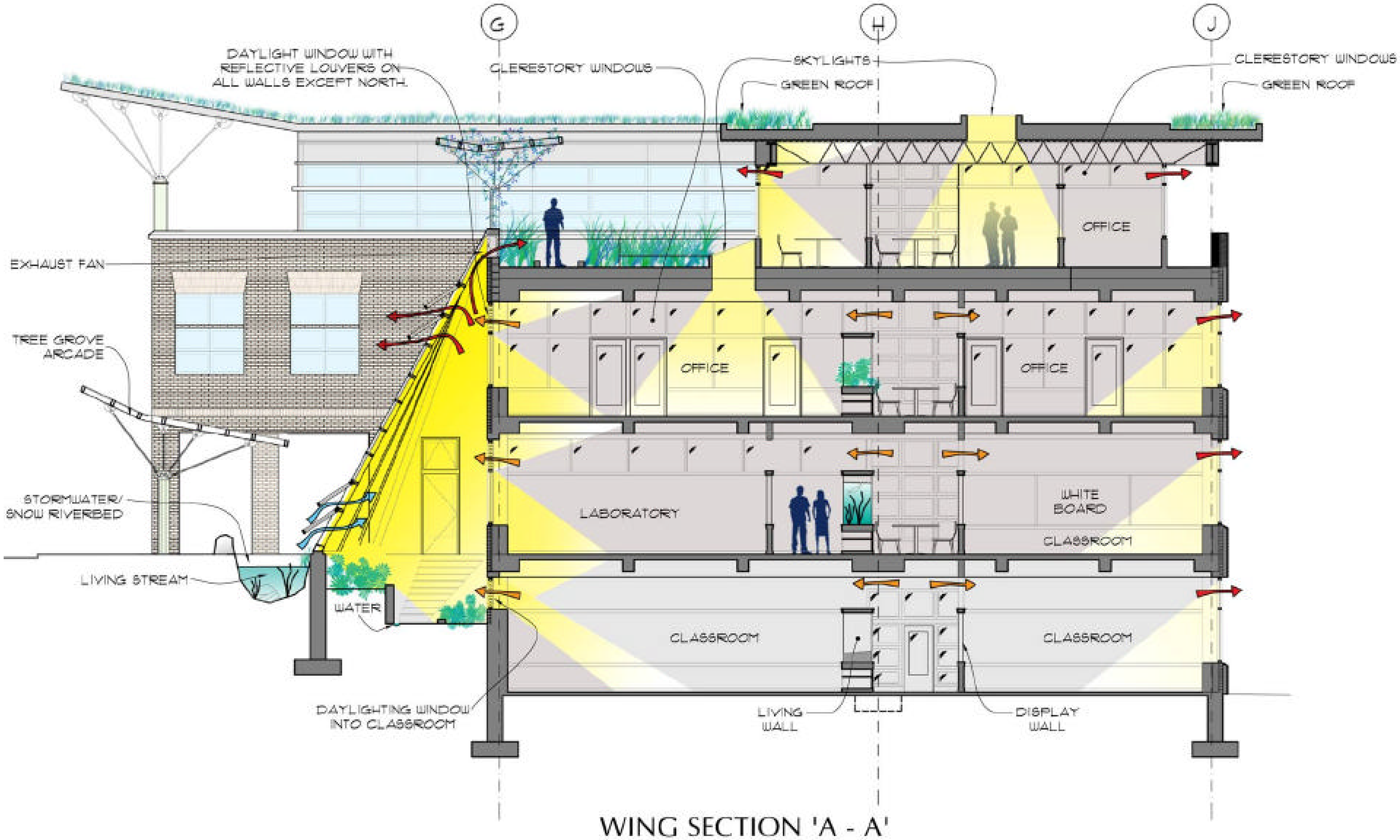
- Model for Designing a Building as Education Program
  - Continuous engagement and meetings of students, staff, faculty, UVM facilities and operations personnel, and more
- Highest Standards for Competition
  - Specific requirements for “green building” experience and excellence
  - 24 National and Regional Firms Submitted Proposals
  - 4 Top Firms Selected for Final Presentations (2 VT, 2 Out-of-State)

Competition Winner: Maclay Architects and Associates
Waitsfield, Vermont

The
UNIVERSITY
of **VERMONT**

The Rubenstein School

of Environment and Natural Resources



Goal: building (as) an ecosystem

producing a net positive contribution to built capital, human capital (education), social capital (community interactions) and natural capital (ecosystem services)

The UNIVERSITY of VERMONT

PRACTICE WHAT WE TEACH

Incorporate ecological design principles into building design, renovation and construction

- model for energy efficiency
- minimize harmful substances
- “green certified” forest products (from our lands)
- recycled steel, wood, and other materials
- innovations in heating, cooling, wastewater trtmt
- cost effectiveness

“c

Buildings become active “learning centers”, part of the curriculum, and models for what can be done

Opportunities for Leadership in Integrated, Transdisciplinary

Research Teaching Service

Ecological Economics

Ecological Design

Environment and Business

Human and Ecosystem Health

The UNIVERSITY of VERMONT

The Environmental University: Why Does it Matter?

<u>Situation:</u>

- growing "global environmental debt"
- alteration of ecosystem processes threatens quality of life and economic vitality just as economic deficits
- ecological, social, political, & economic implications

<u>Need :</u>

- to educate a new generation of leaders, citizens, and ecosystem thinkers who understand "interconnectedness"
- have knowledge and skills to imagine solutions, design alternative systems, develop ecologically based economies
- build capacity for new ecologically based enterprises

The UNIVERSITY of VERMONT

Why UVM?

--Vermont - history, ecology, culture, economy, and working landscape

-- Strong Academic Programs - environmental interest and expertise across the campus; history and reputation for environmental excellence
New graduate certificate in Ecological Economics

-- Environmental Council - proactive, engaged, institutional conscience

-- Centers/Institutes - to serve as bridges and integrators
- i.e. Gund Institute

Four Visions of the Future

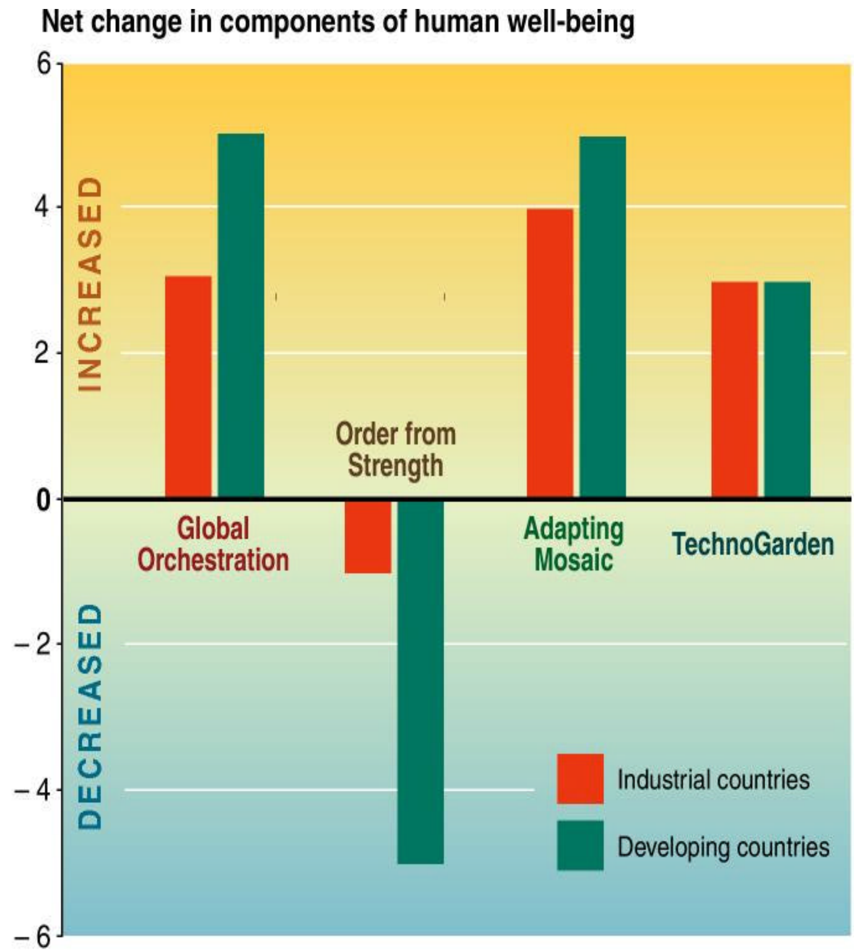
World View & Policy	Real State of the World	
	Optimists Are Right (Resources are unlimited)	**Skeptics Are Right** (Resources are limited)
Technological Optimism Resources are unlimited Technical Progress can deal with any challenge Compitition promotes progress; markets are the guiding principle	**Star Trek** Fusion energy becomes practical, solving many economic and environmental problems. Humans journey to the inner solar system, where population continues to expand (mean rank 2.3)	**Mad Max** Oil production declines and no affordable alternative emerges. Financial markets collapse and governments weaken, too broke to maintain order and control over desperate, impoverished populations. The world is run by transnational corporations. (mean rank -7.7)
Technological Skepticsm Resources are limited Progress depends less on technology and more on social and community development Cooperation promotes progress; markets are the servants of larger goals	**Big Government** Governments sanction companies that fail to pursue the public interest. Fusion energy is slow to develop due to strict saftey standards. Family-planning programs stabilize population growth. Incomes become more equal. (mean rank 0.8)	**EcoTopia** Tax reforms favor ecologically beneficent industries and punish polluters and resource depleters. Habitation patterns reduce need for transportation and energy. A shift away from consumerism increases quality of life and reduces waste. (mean rank 5.1)

from: Costanza, R. 2000. Visions of alternative (unpredictable) futures and their use in policy analysis. *Conservation Ecology* 4(1):5. [online] URL: **http://www.consecol.org/vol4/iss1/art5**

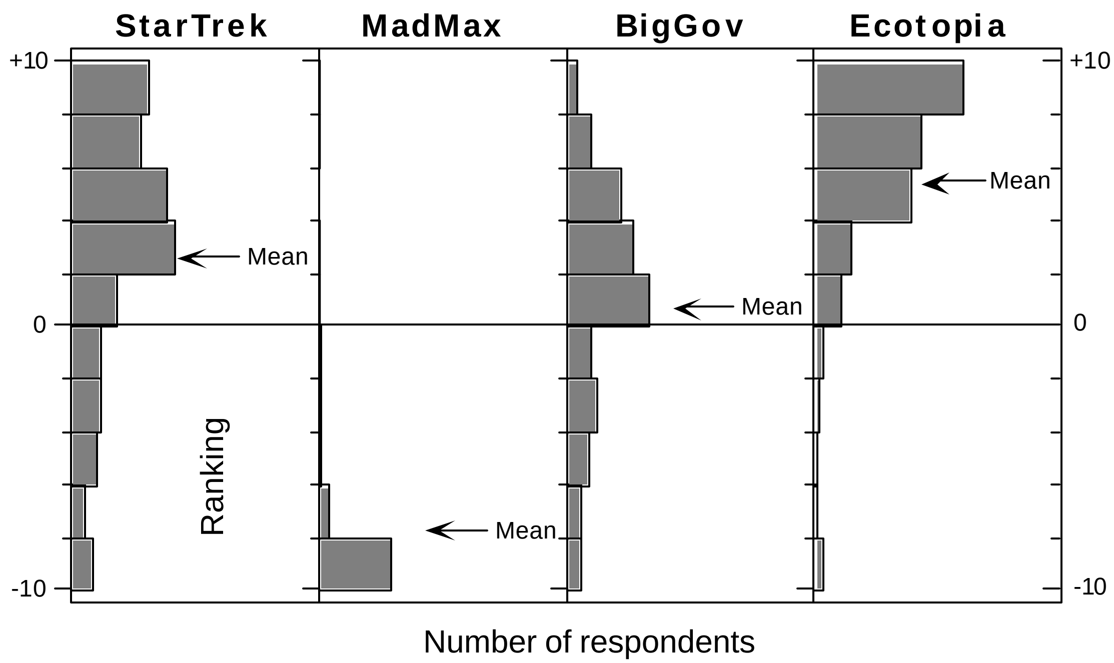
Changes in human well-being under Millennium Assessment scenarios

- In three of the four MA scenarios, between three and five of the components of well-being (material needs, health, security, social relations, freedom) improve between 2000 and 2050

- In one scenario (*Order from Strength)* conditions are projected to decline, particularly in developing countries



Source: Millennium Ecosystem Assessment

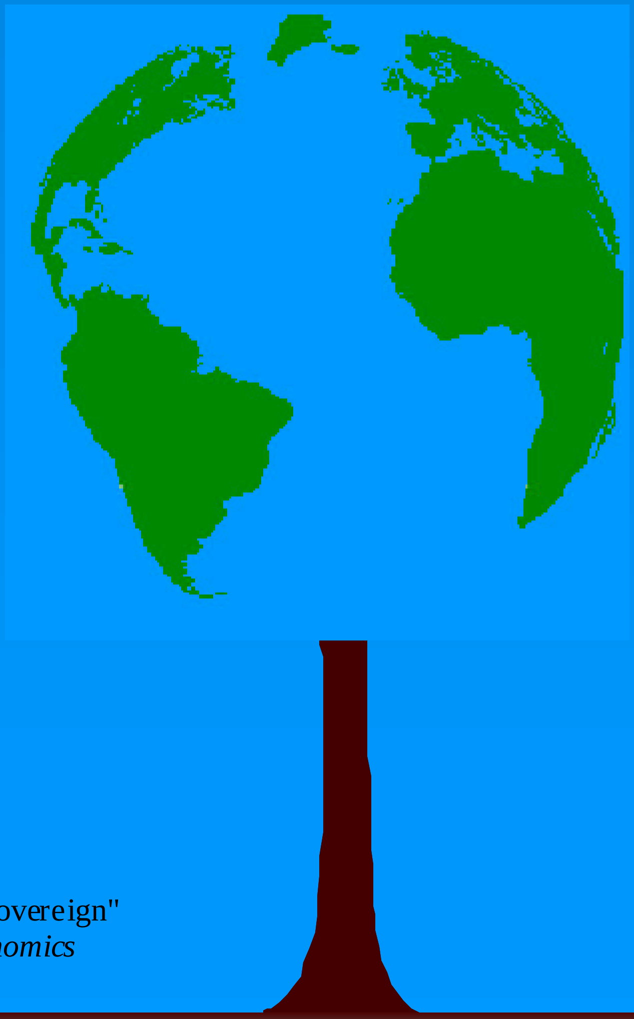

StarTrek
MadMax
BigGov
Ecotopia
+10
0
-10
+10
0
-10
Mean
Mean
Mean
Mean
Ranking
Number of respondents

Two Tier Social Decision Process*

Tier 1 (Reflective)
Social concensus on broad goals and vision of the future, combined with scientific models of dynamic, non-equillibrium, long-term ecological economic interactions.
Here, environmental problems are classified according to the risk to social values they entail.

↓↑

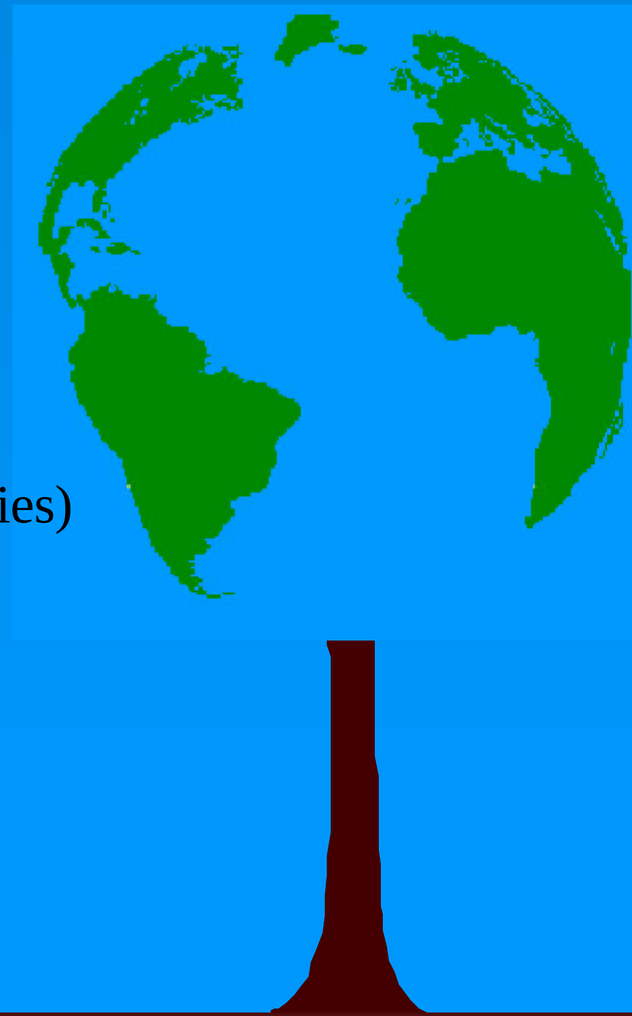
Tier 2 (Action)
Resoulution of conflicts mediated by markets, education, legal, and other institutions, combined with short-term, equillibrium models of interactions and optimality.
Here, particular action criteria are applied, acted upon, and tested in particual situations.



* from: Norton, B., R. Costanza, and R. Bishop. 1998. The Evolution of Preferences: Why "Sovereign" Preferences May Not Lead to Sustainable Policies and What to Do About It. *Ecological Economics* 24:193-212

Envisioning a Sustainable and Desirable America

The vision so far (see http://www.uvm.edu/giee/ESDA)



<u>World View</u>

Humans as a part of nature
Steady state, ecological economy
Goal quality of life rather than consumption

<u>Natural Capital</u>

Protected as essential life support
Depletion heavily taxed

<u>Built Capital</u>

Runs on renewable energy and natural capital
Emphasis on quality rather than quantity
Small communities rule (both within and outside cities)

<u>Human Capital</u>

Balance of synthesis, analysis, and communication
Meaningful, creative work and leisure
Stable populations

<u>Social Capital</u>

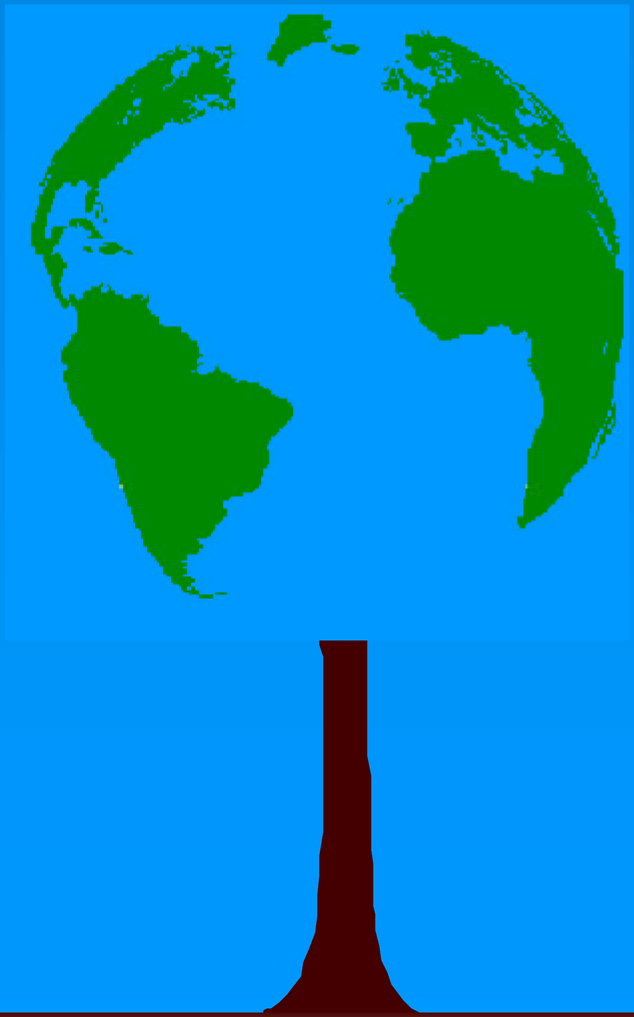
A primary source of productivity and well-being
“Strong” democracy

Some Implications for Policy and Implementation:

Making the Market Tell the Truth

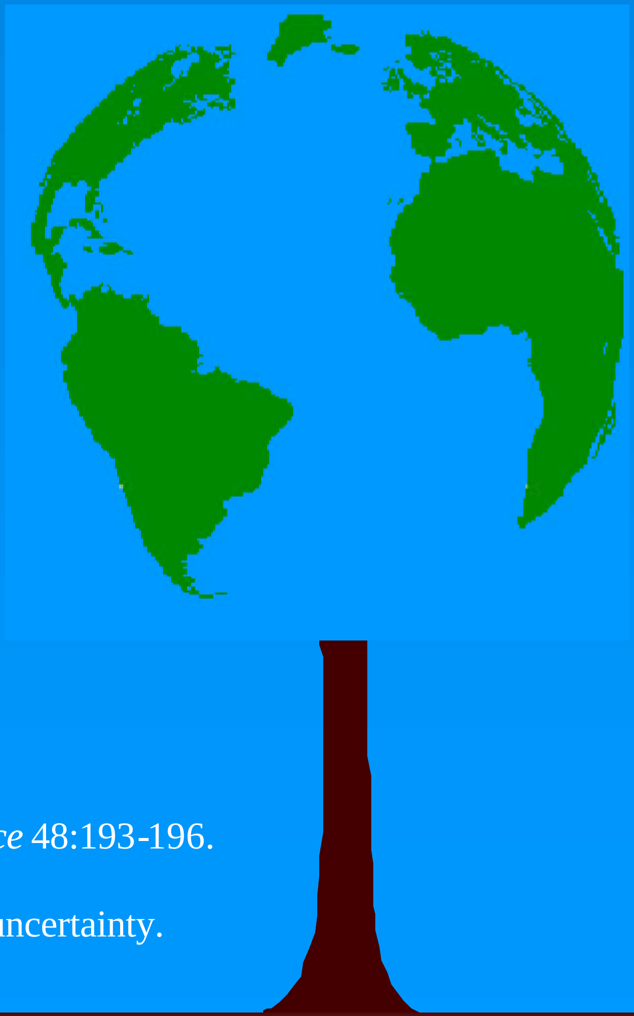
Dealing with Uncertainty: Changing the Burden of Proof

Sustainable Trade



Making the market tell the truth

In general, privatization is NOT the answer, because most ecosystem services are public goods. But we do need to adjust market incentives to send the right signals to the market. These methods include:



•Ecological tax reform (tax bads not goods, remove perverse subsidies)

•Full cost pricing (i.e. www.trucost.org) linked to investment fund management

•Ecosystem service payments (a la Costa Rica)

•Conservation easements and concessions (a la Conservation International)

•Environmental Assurance bonds to incorporate uncertainty about impacts (i.e. the Precautionary Polluter Pays Principle - 4P)

See:

Bernow, S., R. Costanza, H. Daly, et. Al.. 1998. Ecological tax reform. *BioScience* 48:193-196.

Costanza, R. and L. Cornwell. 1992. The 4P approach to dealing with scientific uncertainty. *Environment* 34:12-20,42.

Sustainable Trade:

Remove environmental and labor externalities FIRST (via the previous methods) THEN allow trade to occur. This will allow trade to create real, socially beneficial gains, rather than mislabeling externalized costs as benefits of trade.

See: Ekins, P., C. Folke, and R. Costanza. 1994. Trade, environment and development: the issues in perspective. *Ecological Economics* 9:1-12.

Costanza, R., J. Audley, R. Borden, P. Ekins, C. Folke, S. O. Funtowicz, and J. Harris. 1995. Sustainable trade: a new paradigm for world welfare. *Environment* 37:16-20, 39-44.

Surprise Washington!
US is already halfway to Kyoto!

Table 1. US States and Cities with Climate Control Protocols (CCPs)

	Population (thousands)	% of Total US Population	Gross Product 2003 (billions)	% of Total GDP
States with CCPs				
Connecticut	3,483	1.20%	172	1.58%
Maine	1,306	0.45%	41	0.38%
Massachusetts	6,433	2.21%	297	2.73%
New Hampshire	1,288	0.44%	49	0.45%
Rhode Island	1,076	0.37%	40	0.36%
Vermont	619	0.21%	21	0.19%
New York	19,190	6.59%	822	7.53%
Subtotal	33,396	11.48%	1,442	13.21%
States developing CCPs				
California	35,484	12.19%	1,446	13.26%
Oregon	3,560	1.22%	120	1.10%
Washington	6,131	2.11%	245	2.24%
Subtotal	45,175	15.52%	1,812	16.60%
Major Cities with CCPs (not included above)				
Chicago, IL	2,869	0.99%	366	3.36%
Philadelphia, PA-NJ	1,479	0.51%	201	1.84%
Atlanta, GA	423	0.15%	188	1.72%
Minneapolis-St. Paul, MN-WI	654	0.22%	135	1.24%
Newark, NJ	278	0.10%	105	0.96%
24 Other Municipalities	8,172	2.81%	870	7.97%
Subtotal	13,875	4.77%	1,865	17.10%
Total	**171,018**	**31.77%**	**5,119**	**46.91%**
United States	291,000		10,911